Global Citizenship Education

in the Biology Classroom

An Exploratory Study in Scotland

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ABSTRACT

In the United Kingdom and Europe, there are ongoing efforts to reform science education in order to provide students with an understanding that transcends the scientific knowledge itself and that is relevant to citizenship. This exploratory study investigated the opportunities and the constraints for teaching Evolutionary Biology (EB) in the context of Global Citizenship Education (GCE). The study focuses on secondary school education in Scotland, at the time of a major curricular reform. My specific interest in the educational system of Scotland stemmed from the fact that the Scottish National Curriculum, the *Curriculum for Excellence* (CfE), encourages integrated interdisciplinary approaches to citizenship education, where biology is one component of a holistic citizenship curriculum and biology teachers are required to consider citizenship issues within their subject teaching.

Evolution, in biology, is the general framework for understanding life and, at its base, is about the common ancestry of living beings. Therefore, EB is substantially the theory of Phylogenetic Trees. In addition, EB with Population Thinking in taxonomy provides arguments against the typologist assumptions in human classification, underpinning the biologisation of cultural identities.

Through a document analysis and an empirical phenomenographic study, I explored the patterns in the interplay between teaching EB and GCE, within the compulsory Scottish secondary school science curriculum. The document analysis, which consisted in the analysis of official science education documents and biology textbooks, revealed that only microevolutionary concepts play a major role in the documents and in the textbooks. Macroevolution, human evolution, phylogeny and population thinking are omitted by the compulsory science specifications of the *CfE* and textbooks. However, the texts illustrating the EB specifications are open texts, in Eco’s taxonomy. Open texts are incomplete texts that can be freely interpreted and cooperatively generated by

the readers. Therefore, teachers, with their knowledge and interests, can complete the “unsaid” and interpret creatively the biology specification.

The phenomenographic inquiry involved twenty-one biology teachers from thirteen different Local Authorities of Scotland who participated in semi-structured, in-depth interviews. From the phenomenographic analysis of the transcripts of the interviews, three different ways of thinking and reporting about the role of teaching biology for the purpose to educate for global citizenship emerged. The first conception relates the biology syllabus to issues of social justice, the second to environmental issues and the third focuses on the individual development of students.

This body of work provides insights into some of the issues associated with the problematic teaching of evolutionary biology with the aim to promote cosmopolitan values, in secondary school. Moreover, it adds to the research in global citizenship education, by providing evidence from the conceptions of biology teachers involved in the implementation of curricular innovation.

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I dedicate this submission with love to my daughter Lia, who has just started her academic studies.

Author’s Declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature:

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Abbreviations

CE	Citizenship Education
CfE	Curriculum for Excellence
EB	Evolutionary Biology
GC	Global Citizenship
GCE	Global Citizenship Education
NOS	Nature of Science
SB	School Biology
SQA	Scottish Qualifications Authority
SSI	Socioscientific Issues
STS	Science Technology Society

Chapter 1: Introduction

1.1 Chapter overview

This chapter provides an introduction to this thesis which engages with conceptions of teaching evolutionary biology in the context of global citizenship education during the implementation of a curricular reform in Scottish schools. In this introduction, three key definitions are provided: the definitions of Global Citizenship Education, Evolutionary Biology and Biological Citizenship. Given the ideological nature of the content of my research, I then disclose my own perspective, as a European secondary school science teacher, on the role of evolutionary biology in educating for global citizenship. Finally, I provide an overview of my research and conclude the chapter by describing the structure and the contents of this thesis.

1.2 A working definition of Global Citizenship Education

The idea of global citizenship is older than written history and originated independently in different parts of the world, in different cultures and different times (Appiah, 2008). Global citizenship does not currently have a univocal meaning. However, since Diogenes, the very first individual who has been reported to have identified himself as a citizen of the world, the term has been generally used as a metaphor to indicate the status, the ideal, the dream of belonging to some sort of global community. In other words, the defenders of global citizenship, rather than being motivated by a project of global domination, generally share the feeling of a sense of belonging to humanity as whole.

In the present global world, however, a world in which each of us can realistically imagine contacting any of the other seven billion humans, there seem to be insurmountable frontiers dividing the global community aspired to by cosmopolitans. To put it in Nussbaum's words, these frontiers are primarily frontiers of justice (2009). In fact, a global interwoven system of oppression based on gender, ethnic and social belonging makes inequalities the ruling features of the human community.

At the beginning of the twenty-first century, the wealth of the richest 1% equals that of the poorest 57%; the 200 richest people in the world are worth more than the total income of 41% of the world population; 6 million children under the age of five are dying each year because of malnutrition; 1.4 billion people, of which 1 billion are women, are dying by 40 years of age; 98% of these individuals are living in the so-called developing world (Tully, 2008). In addition, economic crises, conflicts, terrorism and fundamentalisms are causing waves of migrations, resulting in societies characterised more and more by inequalities. To add to this picture, humanity seems to run a deadly risk because of the problem of the global warming.

These are some of the reasons why contemporary educational thinkers, such as Appiah and Nussbaum, advocate for education which aims to foster a cosmopolitan spirit in young people, supported by using scientific arguments. In this thesis, by the term global citizenship education I mean education for the cosmopolitan spirit that is “the very old ideal of the cosmopolitan, the person whose primary allegiance is to the community of human beings in the entire world” (Nussbaum, 1994: p.1).

1.3 A working definition of Evolutionary biology

Evolutionary biology is the study of living beings in the light of evolution that is the process of descent with modification that originates with provisional types of living beings from ancestral forms. Evolutionary biology interprets life phenomena comparatively, assumes that life phenomena cannot be understood without understanding their past and devotes much of the study of contemporary species to the understanding of the influence of shared phylogenetic history (Harvey and Pagel, 1991). In evolutionary biology, contemporary species are classified on the basis of common ancestry and are represented as branches of phylogenetic trees which are diagrams that, like genealogic trees, allow us to estimate the degree of kinship among different branches.

Evolutionary biology is the branch of science that explains adaptation and biodiversity with natural selection, a theory that was first presented at the Linnean Society of London on 1 July 1858, as a joint paper between Charles Darwin and Alfred Russel Wallace (Darwin and Wallace, 1858). The theory became overwhelmingly accepted by biologists all over the world relatively soon after Darwin published *On the origin of species*, in 1859. Contemporary evolutionary biology derives from the Modern Synthesis that is the scientific theory that in the forties integrated Darwinian and Mendelian concepts in a single framework with evolution as a key and universal explanatory framework for understanding life on this planet (Kutschera, 2004).

At present, Evolutionary Biology integrates several disciplines, from genetics to molecular biology, from anatomy to physiology, and relates biology to other fields of knowledge, such as mathematics and sociology (Tidon and Lewontin, 2004). Its applications encompass a wide range of biotechnologies used in medical research and in agriculture, among others. In addition, current practical applications of phylogenetic methods include a range of diverse objectives such as reconstructing invasion routes of harmful organisms, conservation planning and combating crime (Carroll et al, 2014).

1.4 A working definition of Biological citizenship

Biological citizenship may have a variety of contrasting meanings that, in human history, quite often played nefarious roles, but sometimes also had empowering meaning for citizens. The identification of an individual through a biological citizenship identity may have in fact either the purpose of discriminating against the individual or of promoting equality of opportunity. For the purposes of this thesis, the meaning of biological citizenship adopted is that of the categories by which we are sometimes identified, as citizens, on the basis of biological features of our body, such as gender or skin pigmentation.

Biological citizenship based on the fact that the differences among individuals that characterise the citizen's biological identity, can sometimes be the object of conflict in society with regard to their actual biological magnitude (Pigliucci, 2013). In fact, some reports claim that the biologisation of cultural categories is the actual basis for creating biological citizen identities (Appiah, 1985; Gould, 1996; Pigliucci and Kaplan, 2003; Rose, 2007). This might be related to the fact that some of the features at the centre of societal debate are characteristics of our body that are consequences of brief evolutionary processes due to the selective pressure of climate. Although such biological differences between individuals are generally very small, we tend to perceive them as much bigger because we tend to notice the external body features of an individual (Cavalli Sforza and Cavalli Sforza, 1995).

Consider for instance the case of Ms Ann Dunham's son. Ms Ann Dunham was an American anthropologist whose name is written in human history because she was the mother of Barak Obama, the former President of the United States. She was born in Kansas from parents of predominantly Anglo-Saxon ancestry. She was white and married a black African student, Mr Barack Hussein Obama Sr. Although the answer is known, it is legitimate to wonder why Barack Obama, being half Anglo-Saxon and half Black African, is considered the first African American, rather than the 44th Anglo-Saxon American President of the United States.

The obvious answer lies in the pigmentation of Obama's skin. However, in each of Mr Obama's cells there are approximately two metres of DNA and a very small fragment of this, no longer than a few millionths of a metre, encodes skin colour. As a matter of fact, half of this DNA fragment was inherited from the mother and resides in one chromosome. The second half, inherited from his father, resides in another chromosome. The two above-mentioned chromosomes are said to be homologues, as they codify for the same information (e.g. skin colour). The interaction between such DNA homologue fragments and environmental factors is responsible for Obama's skin pigmentation. From a biological point of view, the relevance of such DNA fragments is comparable to those responsible for the blood types of an individual. However, from a socio-cultural point of view it is the very reason for which it is not generally accepted to identify Mr Obama as an Anglo-Saxon-American person.

It is not the aim of this thesis to understand why one person is categorised with one biological identity rather than with another. However, what is relevant to this study, as detailed later, is what Hull (1965a and 1965b) considers the effect of essentialism in taxonomy. That is the pre-Darwinian tendency to identify an individual as a carrier of some features considered essential properties of a given human group. For instance, skin pigmentation is one of such features for identifying an individual as an Anglo-Saxon person. Later in this thesis, I will show how the Darwinian revolution, with population thinking (Mayr, 1975), has represented a critique to such an Aristotelian essentialism.

1.5 A personal stance as a European secondary school biology teacher

I have been teaching science for nearly thirty years in Italian secondary schools and my PhD studies are only a temporary suspension of my job as a teacher. Hence, this research is first of all, a study carried out from the point of view of a European secondary school science teacher, investigating the role of educating for global citizenship through school biology.

My research is framed at the intersection between two different theoretical frameworks: the cosmopolitan framework, in citizenship education, and the post-Darwinism paradigm, in science education. Within the latter, as a science teacher, I would argue that science is to a large extent the study of the evolution of systems in time. Evolution is the central organizing principle of all the natural sciences (Lerner, 2000): the evolution of the universe, stars and planets, in astronomy; the evolution of lithosphere, oceans and atmosphere, in Earth Science; and the evolution of living beings in biology. For this reason, I believe that an understanding of biology without an understanding of evolution is incomplete (Bishop and Anderson, 1990) and without knowledge of natural selection it is impossible to understand the diversity and the complexity of living beings (Gregory, 2009). I fully agree with Dobzhansky's arguement that 'nothing in biology makes sense except in the light of evolution' (1973: p.125).

As an educator, I have a cosmopolitan outlook and my interest and special concern is about how educators can support learners and can contribute to preventing misconceptions that might lead to racist and discriminatory views. My thesis is grounded in the belief that there is a universal standard of life, not informed by race, ethnicity and gender or by any other human taxonomic category. I therefore hold that the main aim of education is the idea of developing students' ability to critically judge the thoughts and actions which occur in society and, to put it in Nussbaum's (1994) words, to cultivate the capacity to look critically at what in one's society is taken for granted and to accept only what survives with scientific consistency and justification.

From such a point of view, I believe that evolutionary biology might challenge students to critically investigate examples such as racism, cultural identity, biological citizenship, biological diversity and migration, by providing resources for critical discussions on a number of such contemporary issues. These include the unsolved problem of justice in treating non-human animals, the persistent attempt to limit woman's rights and the problem of extending justice to all citizens in the world (Nussbaum, 2012).

1.6 An overview of this research

In this section, I provide an overview of my research, setting the research background, introducing the conceptual framework, the literature reviewed and the research questions, and outlining the methodology and the findings.

1.6.1 The background of this research: historical and geographical context and European trends in reforming school curricula

In Scotland, the educational system, along with the legal system and the Church, has always been distinctive from the rest of the United Kingdom and a key indicator of national identity (Humes, 2013). At present, the so-called *Curriculum for Excellence* (CfE) is the national curriculum for state Scottish schools. It represents a recent reform programme that, unlike the three previous curricular reforms which were covering limited age ranges (i.e. Standard Grade of 1977, 5-14 programme of 1987 and Higher Still of 1992), is covering learning for the whole age range 3-18.

In the UK, since the election of the Labour government in 1997, there has been a renewed interest in citizenship education in all four countries of the United Kingdom (Kerr et al., 2008). In addition, Scottish education traditionally had citizenship as a core purpose in reforming school curricula (Munn and Arnott, 2009). For instance, in Scotland, the aim of addressing citizenship in education dates back at least to 1962 with the introduction of Modern Studies as a subject that provided secondary schools with the opportunities to cover social and political issues in the curriculum. The CfE seems to be framed in such a tradition as one of its features is that citizenship education is an explicit key overarching purpose (Munn and Arnott, 2009).

Since the establishment in 1999 of a Scottish Parliament, Education has been one of the few completely devolved powers. The new Scottish parliament focused on education as a main field of interest (Humes, 2013). In 1999, a national review group was set up in order to set out the key purposes of citizenship education and the ways in which these might be pursued in schools (Munn and Arnott, 2009). In addition, citizenship was seen as congruent with the five National Priorities (i.e. Achievement and Attainment; Framework for Learning; Inclusion and Equality; Values and Citizenship; Learning for Life) established by the first Education Act by the first Scottish Parliament, in 2000 (Munn and Arnott, 2009). Furthermore, in 2002, a large-scale public consultation was launched, with the aim to canvass public views on future policy (Humes, 2013). The reports following this consultation highlighted the importance of schooling as a means of promoting social equality (Munn and Arnott, 2009).

To understand the process of Scottish curriculum development, the particular international climate in which the *CfE* arrived on the scene must also be taken into account (Humes, 2013). Humes (2013) maintains that, at that time, a number of factors were influencing Scottish educational policy: the tables comparing results in different countries in language, science and mathematics produced by the Organisation for Economic Cooperation and Development (OECD); the pressure exerted by international economic powers, demanding more adaptability and mobility in employment; and an international agenda for changing and improving efficiency in the public sector, defining clear targets of accountability. It is also important to consider that in several European countries, there is an urge for global citizenship education to face the challenges posed in western societies by migration, multiculturalism, racism, globalisation and lack of social engagement affecting young people (Naval and Jover, 2006).

In fact, the need to solve the problems related to multiculturalism and migration has resulted in several European countries including, as a common educational aim, the encouragement in young people of the democratic principles of human rights and equality. *CfE* seems to reflect such a European trend that conceives education as a means to enable students to know, to do, to live together and to be (Naval and Jover, 2006). In fact, the explicit aim of the *CfE* is to lead young Scottish people to become successful learners (i.e. to know), effective contributors (i.e. to do), responsible citizens (i.e. to live together) and confident individuals (i.e. to be). As a result, at least at a rhetoric level, in the Scottish curriculum, every teaching subject is in principle an integrated component of an holistic citizenship curriculum which has at its foundation the adoption of integrated interdisciplinary approaches to citizenship education.

In such a European and Scottish educational setting, science educators and curriculum developers are called to provide students with scientific curricula that transcend scientific knowledge itself and that are relevant both to individuals and society (Sadler et al., 2006).

1.6.2 The role of teachers in pursuing meaningful educational goals

Within the purpose of educating for citizenship through school science, Osler (2011) describes contrasting ways in which science teachers respond to the demand of contributing to aspects of citizenship learning. While some teachers identify themselves as citizenship educators, others perceive of themselves as instructors of a specific subject, such as chemistry or biology. Moreover, literature reports constraints in developing the link between science and citizenship education, from the perspective of science educators (Davies, 2004).

In addition, the reformed Scottish curriculum raised another key educational issue: what is the role that teachers must have in pursuing the educational aims of a curriculum. In fact, in the CfE, Humes (2013) points out the tension between the view of those who believe that teachers are expected simply to follow central directives and prescriptive curricula and, on the other side, the view of those who argue that teachers should be active and creative interpreters of the curriculum. In harmony with the latter point of view, Biesta, Priestley and Robinson (2015) maintain that “because of the complexities of situated educational practices, teacher agency is an indispensable element of good and meaningful education” (p.1).

Research indicates that teachers’ beliefs are a decisive component in reforming education and in the implementation of curricula (Bybee and Mau, 1986; Pajares, 1992; Handal and Herrington, 2003). Van Driel et al. (2001) argue that educational reforms have sometimes been unsuccessful because they did not take into account teachers' existing knowledge, beliefs, and attitudes. The role of teachers’ beliefs and attitudes is, in fact, critical in predicting their classroom practices, intentions and behaviour (Czerniak and Lumpe, 1996). This is also consistent with Bandura's theory (1986) that people's beliefs are the main motivating factors underpinning the decisions they make in their life.

1.6.3 An overview of the literature reviewed and possible research gaps

The general purpose of this thesis is to inquire into the opportunities and challenges for teaching evolutionary biology with the aim of promoting global citizenship education. Therefore, within the literature review section, I have first explored the meaning of global citizenship in the educational literature. This review shows that global citizenship education is sometimes seen as a remedy for all the problems generated in western societies by issue related to migration and multiculturalism. However, global citizenship does not have a univocal meaning and, at times, it can constitute a complex field of contested language, activities, institutions and processes. This thesis is linked to the trend of global citizenship education that is rooted in the Sophist philosophers who argued, in the 5th century BC, for the ideal of allegiance to all humanity of the world, rather than to the citizens of a city.

In the second section of my literature review, I have explored the interplay between science education, citizenship education and scientific literacy for democratic participation. The examples of the role that was played by chemistry in the Great War, that of physics in the Second World War and the numerous environmental catastrophes that have been caused by the application of science and technology, highlight that science cannot be presented to students simply as a neutral system of knowledge production. In the history of western democracies, the interplay between school science and citizenship education has been complex. The main contemporary approach to citizenship education through school science, the so-called socio-scientific issues framework, consists of promoting students' participation in debate on issues with bases in science and that have ethical relevance.

The literature review also shows that the interpretation of how scientific literacy can promote democratic participation in society can be seen through the lens of four main frameworks: the *deficit*, the *deliberative*, the *science education as praxis* and the *science education for democracy through conflict and dissent* frameworks (Levinson, 2010). Within the deficit framework, scientific knowledge moves along the hierarchy of scientists, teachers, students. At school, teachers are science's representatives and help the students in constructing their socially relevant scientific knowledge. Within the deliberative framework, scientific knowledge resides in experts while teachers promote understanding of the scientific method and critical thinking. The development of trust in science is one of the main aims of these two models, rather than the development of expertise.

The other two frameworks are more radical. Within the *science education as praxis framework*, scientific knowledge is contestable and the social, ethical and political biases need to be made explicit and school science must be part of interdisciplinary projects in students' local communities. In such a context, school science provides students with the need-to-know scientific knowledge relevant for addressing a shared problem. In this way, students collaborate with educators, scientists, farmers, environmentalists and local policy makers (Roth and Désautels, 2004). The even more radical *science education for democracy through conflict and dissent* framework aims at disclosing the possible causes of social injustice underpinning a dominant scientific knowledge in society, placing a strong socio-political element into learning. Within this framework, the concept of *biological citizenship* has been developed for indicating all of those citizenship projects that identify citizens with supposed biological features.

In principle, evolutionary biology should provide the unified framework to interpret the magnitude of such features from a biological point of view. Over the last 50 years, our understanding of evolutionary biology has advanced hugely, however, these advances have been communicated poorly to the public and to educators and learners within the social sciences (West et al., 2011). For this reason, in the last section of my literature review, I have focused on the pedagogical and philosophical issues related to teaching evolutionary biology in the secondary school. Research in education reports confusing findings about the interrelationships among student understanding, acceptance, and belief in evolutionary biology (Smith, 2010a and 2010b) which might compromise the relationship between school biology and citizenship education.

From the findings of the literature review, different orders of barriers seem to be hindering the prospect of teaching evolutionary biology for promoting global citizenship in secondary schools. Problems related specifically to teaching evolutionary biology are reported all over the world; misconceptions are reported even among biology teachers; the cyclical re-emergence of biological determinism surfaces in the contentious debate about the so-called human races, ethnicity and gender; and the resistance of some biology teachers when they are asked to add socio-scientific issues to an already overcrowded secondary school biology specification.

In addition, in secondary schools evolutionary, biology is linked to citizenship education through the study of biotechnologies, such as the production of genetically modified food and the practices of cloning. Such applications are considered socio-scientific issues that, by raising them as bioethical dilemmas, can be the objects of classroom discussions and debates with the aim of fostering democratic skills and participation. However, the intersection among global citizenship education, the common descent theory, the advances in genomics and the educational strategies to tackle discrimination based on biological citizenship, does not seem to emerge as an issue from the science education literature. For instance, the juxtaposition between the racialising and naturalisation of cultural differences between individuals on the one hand and the scientific delegitimization of human races and ethnicity on the other does not emerge as a socio-scientific issue in school biology. On the contrary, a misunderstanding of natural selection seems to prevail, along with essentialist positions that treat human groups as real entities, rather than statistical abstractions.

1.6.4 Rationale, research questions and the development of an empirical research model

In 2008, seventeen academics at Stanford University endorsed an open letter presenting guiding principles on the use of racial categories in human genetics (Lee et al., 2008). The letter emphasised that “there is no scientific basis for any claim that the pattern of human genetic variation supports hierarchically ranked categories of race or ethnicity” [and that] “research in human genetics has highlighted that there is more genetic variation within than between human groups” (p.2). The arguments raised by the above-mentioned open letter are sustained by the advance in genomics and evolutionary biology and are shared by philosophers, geneticists, biologists, social scientists and educators. They substantially point out that science clearly shows that, from a biology point of view, there are no grounds for racial and ethnic categories.

I started my research with the aim of investigating the opportunities and the constraints for teaching evolutionary biology in the context of global citizenship education. The literature review clarified a number of constraints but added little about the opportunities. As a matter of fact, a clear and explicit link between school evolutionary biology and global citizenship education does not seem to be an interest in the educational research and literature. In the “age of Genomic Medicine” (Rose, 2007, p.155), more than one question is still without answers after my literature review. For instance: should the knowledge on the scientific regardless of racial categories be an integrated part of secondary school science curricula? Should the advances in genomics at the base of the abovementioned open letter be part of the requested standard of citizens’ and students’ scientific literacy? Should curriculum developers integrate into science compulsory specifications such as advances in evolutionary biology? Should the socioscientific issues debated in the biology classrooms include the issue of whether racial categorization is anything different than the pernicious reification of historically destructive typologies?

Evolutionary biology, with Darwin's and Wallace's theory and the subsequent integration of genetics and molecular biology, is a scientific theory that connects every human being to any other living being on this planet, not metaphorically, but on biological bases and provides solid scientific evidence, based on human genetics studies, showing biological equality . Therefore, evolutionary biology, to put it in Desmond's and Moore's words (2010), constitutes a revolutionary scientific theory of brotherhood of races and species. In literature it is not clear if such a revolutionary theory should provide secondary school biology teachers with the scientific basis for studying and discussing issues of biological citizenship and citizenship discrimination. In other words, in research and literature it is not known to what extent secondary school evolutionary biology should inform concepts of biological citizenship.

In addition, while much research has addressed teachers' opinions and attitudes concerning the evolution-creation controversy, few studies have investigated other teachers' understanding related to evolutionary theory (Rutledge and Warden, 2000). For instance, what biology teachers think about disclosing the common misconception about the extent of the biological differences among races, ethnicities and genders, during the biology classrooms, does not seem to be the object of educational research. Whether biology teachers think that the common origin theory is relevant for promoting cosmopolitan values is unknown in educational literature and research.

Furthermore, literature also illustrates that microevolutionary mechanisms are taught almost exclusively in secondary schools and both students and teachers still have poor understanding of the processes which operate at the macro level (Catley 2006). Natural selection has become synonymous with evolution, although, increasingly, issues of bioethics, human origins, cloning, etc., are being cast in a light that requires an understanding of macroevolution. "To deny our students access to this debate is to deny the call for universal science literacy" (Catley 2006: p.768).

My research has investigated such a literature gap, under the rationale of the prospect to teach evolutionary biology as a means to promote, in secondary school students, a sense of belonging to humanity and the planet as a whole.

Chance made my research happen in Scotland, during the implementation of a curricular reform that seemed to place at its centre the educational aim of citizenship. Such a circumstance, the abovementioned research gap in evolutionary biology education and the outcome of a research reporting that teachers feel ill-equipped in carrying out citizenship education in an integrated way through the curriculum (Kerr et al, 2003) suggested to me to investigate the following overarching research questions:

1) *To what extent can EB contribute to GCE in secondary school?*
2) *What are the opportunities and the constrains for teaching EB in the context of the GCE, within the compulsory CfE secondary school?*

In the light of these overarching research questions, I designed, with my supervisors, a research model that could inform my study both by texts (i.e. official documents and textbooks) and by teachers (i.e. European colleagues) working in Scotland at the time of my study.

The document analysis consisted in examining science education documents through the lens of elements of content analysis, thematic analysis and semantic analysis of narratives.

The analysis of the official science education documents related to the teaching of biology within the Curriculum for Excellence and the textbooks related to compulsory Scottish secondary school science consisted in elements of content analysis, thematic analysis and semantic analysis of narratives and was specifically driven by the following specific research questions:

1) *Which aspects of school biology and evolutionary biology are prioritised in the CfE? Which aspects of evolutionary biology are undermined or ignored in the CfE?*

2) *To what extent the evolutionary biology specifications in the CfE are relevant for global citizenship education?*

3) *What are the narratives of evolutionary biology emerging in the texts?*

4) *Are there in the texts omissions, simplifications, constraints, lexical sequences, narratives and redundancies?*

5) *Is the reader led to univocal interpretations? Are the analysed texts closed texts that might invoke distorted communication and preclude possible interpretation? Are the analysed texts open, according to Eco's taxonomy?*

In order to get information directly from the teachers, I interviewed twenty-one biology teachers working in secondary schools of Scotland, at the time of the *Curriculum for Excellence* implementation and analysed the transcripts of the interviews using a phenomenographic approach, investigating the following research questions:

1) *How do educators conceive global citizenship education in their role as secondary school biology teachers?*

2) *What are the biology teachers' conceptions of the link between evolutionary biology and global citizenship education? What are the constraints, perceived by the biology teachers, in educating for global citizenship through evolutionary biology?*

1.6.5 An overview of the findings

The analysis of the documents and the textbooks related to the *CfE* had the main purpose of understanding the extent to which the educational setting in which the interviewed teachers were working allowed the link between Global Citizenship Education and School Evolutionary Biology. The main finding is in the fact that such a link seems to be left to the discretion of the teachers. The standard biology framework for the compulsory school does not substantially include any reference to macroevolution, human evolution or human classification. Skills related to tree thinking and population thinking also seem to be excluded from the biology standards for Scottish students (unless they choose to study biology at least at level National 5). Only microevolution, with natural selection, such as resistance to antibiotics, is contemplated in the specification. Therefore, it is likely that macroevolution and tree thinking will generally not be taught. Indeed, in a very busy biology specification, there is no incentive for these topics to be taught (Padian, 2010).

The Scottish curriculum for 11-16-year-old students does not include for the science standard the knowledge and the skills for interpreting a single tree of life, the common origin theory and the genetic equality among so-called “races” or between genders. In fact, the biology framework of the CfE does not even explicitly link evolutionary biology with issues related to biodiversity. This is the educational context within which the participants in my study worked as biology teachers.

Twenty-one biology teachers from thirteen different Local Authorities of Scotland participated in semi-structured, in-depth interviews. The aim of this empirical study was, firstly, to identify different ways in which biology teachers experienced the phenomenon of educating for global citizenship and, secondly, how this related to their interpretations of the links between school evolutionary biology and global citizenship education.

From the phenomenographic analysis of the transcripts of the interviews, responses were coded in three different ways, reflecting three different global citizenship educator identities. These were labelled with their overall meaning, in the following way: (a) social justice identity; (b) environment sustainability identity; and (c) individual development identity. The same patterns emerged when the teachers’ conceptions of the link between evolutionary biology and global citizenship education were explored.

The participants' statements identified in the first conception seemed to focus on evolutionary biology as scientific knowledge relevant for understanding the negligibility of human biological differences and the kinship relationships between people all over the world. In addition, issues such as racism, sexism and a non-hierarchical view of nature were mentioned by the participants. The second conception related evolutionary biology to environmental issues. The responsibility for future generations was an issue of interest. Both the first and the second conceptions were seen as indispensable prerequisites for understanding socioscientific issues and for promoting responsibility in the global community. The third concept that emerged from this study was related to the educational aim of promoting multicultural sensitivity and inclusion. This consisted in focusing on evolutionary biology as a school subject to be taught with constructivist pedagogies, in order to guarantee multicultural sensitivity and the independent development of ideas in students.

The three concepts that emerged from biology teachers' understanding of the link between evolutionary biology and global citizenship education seem to be intertwined variations highlighting different aspects of the same phenomenon, which is the education of students to cosmopolitan values. This is interpreted as a reflection of bias of the sample. In fact, it is likely that the teachers who volunteered to be part of this research are educators who believe in the educational purpose of teaching global citizenship through school biology.

1.7 The structure and content of the thesis

Following this introduction, chapter two reviews the literature from three perspectives: that of global citizenship, of science for citizenship education and of evolutionary biology education. In addressing the literature associated with global citizenship, I have focused on the different meanings by which the metaphor of global citizenship is interpreted in educational settings. This has been chosen because, generally, schools are more familiar with issues of civic education whose meaning is less vague and easier than global citizenship education. The review of the relationship between science education and citizenship education has focused firstly on the historical evolution of this relationship, starting from the early twentieth century. Secondly, there was a focus on the theoretical frameworks in which educators and scholars operate with the aim of making science education relevant to democratic participation in society. Finally, I reviewed the literature dealing with the philosophical and pedagogical issues related to teaching evolutionary biology that might interact with issues of citizenship education.

Chapter three starts by introducing my ontological and epistemological positions followed by the conceptual framework of this research. In the second part of the chapter I have discussed the issues associated with employing the document analysis and the phenomenographic study, including the ethical considerations, and the justification for using such a strategy. Chapter four and chapter five present the findings of the document analysis and the phenomenographic study, respectively. Chapter six provides the reader with my interpretation of the findings and explains their implications and limitations. Finally, in chapter seven I have written the conclusions of my work, providing a brief summary of my research, my personal reflections on what I have discussed, and suggestions for future research.

Chapter 2: A Review of the Literature

2.1 Introduction and chapter overview

In this section I provide, firstly, an account of the procedures I pursued in relation to the data collection for the literature review and, secondly, I provide the reader with an overview of the chapter.

The process of literature search began with a review of my personal archive of material from my previous studies and teaching practices. For my undergraduate biology studies, I was familiar with the work by Darwin, Dawkins and Mayr. During my master studies in teaching adults at the University of Glasgow, I read some of the works by Nussbaum, Appiah, Bandura and Freire. For my personal interest, in relation to my teaching job, I already knew some of the works by Gould, Cavalli-Sforza, La Vergata, Lévi-Strauss and Tanguieff.

As part of the supervisory process, I was made aware of the following studies: the studies by Humes and Munn, respectively on the development of the CfE and the Scottish citizenship education; the studies by Smith on the pedagogical issues of teaching EB, and by Pigliucci, on the concept of biologisation of differences between human populations; and the phenomenographic studies, by Marton and Pong. Therefore, a number of authors and their bibliography represented a solid starting point for my literature search. Other valuable resources were three recent books suggested by academics from the University of Glasgow on GCE (Peters et al, 2008), Scottish Education (Bryce et al, 2008 and 2013) and Research methods (Arthur et al, 2012).

Thereafter I pursued a structured approach to searching, using keywords and database search through the University's Library and Google Scholar. The main keywords were: global citizenship education, citizenship education, citizenship, globalisation, secondary school, CfE, Evolution, evolutionary biology, evolution education, biology education, science education, teachers, cosmopolitanism, cosmopolitan education, phenomenography and document analysis. This search made me aware of key authors in the different fields of research I was investigating.

These sources were helpful in allowing me to address my research questions in different ways. For instance, the work by Marton was the starting point for learning about phenomenography as a research method, and about other researchers using phenomenography in their work. Their studies were useful in addressing my research questions related to the different teachers' conceptions of CE. The studies by Humes and Munn and those related to them helped me in clarifying aspects of the educational context in which the biology teachers were working. The studies by Jenkins and Levinson played a key role in helping me to address my research questions because they provided me with a wider picture and an historical account of the relationship between citizenship education and school science. Additional readings from their bibliography helped me to individuate the theoretical framework of this research, as they made me aware of the socioscientific issues approach and the concept of biological citizenship. By relating these studies to Mayr's critique of essentialism in taxonomy allowed me to follow the research field investigating the persistence of typological thinking in human classification. Using the same criteria, that is by individuating a key author and following his or her bibliography, Luke's works on the analysis of educational documents was very helpful in addressing the research questions about the biology syllabus of the *CfE*. In fact, these sources made me aware of the concept of open and closed texts and provided me with an account of the relation between the linguistic structures and the ideological content.

In this chapter I firstly report, in section 2.2, the different conceptions of global citizenship that I found in the educational literature and research. In section 2.3, I illustrate the outcomes of my investigation into the current views on the interplay between citizenship education and school biology. Specifically, in section 2.3.1, I outline an historical account of that relationship. In section 2.3.2, I report the teachers' views and the frameworks in which scholars and teachers interpret the role of school science for promoting the democratic participation of citizens in contemporary socio-scientific debates. Within these frameworks, I highlight the concept of Biological Citizenship (Rose and Novas, 2004) which is strictly related to the issues of this study.

The emphasis on the concept of biological citizenship stems firstly from the fact that evolutionary biology has been called in to account, sometimes for and sometimes against, the biological identities of citizens. Secondly, any biological syllabus, in theory, allows teachers to discuss the fact that the differences among Europeans, Africans, Asians and any other human populations are biologically very small and consist of a few genes largely selected by climate (Cavalli-Sforza and Cavalli-Sforza, 1995).

In the third and final part of my literature review (section 2.4), I report the pedagogical and philosophical issues related to teaching evolutionary biology and human classification, in the light of citizenship education. In the conclusion of this chapter (section 2.5), I provide the reader with a summary, highlighting possible research gaps.

2.2 The metaphor of Global Citizenship in the educational literature

Citizenship is traditionally related to the duties and the entitlements ascribed to people living in a territory with clear boundaries such a state (Peters et al., 2008) and CE has mainly the purpose to equip students with the capacities to actively contribute to the continuance and the development of democratic societies (QCA, 1998). In addition, contemporary educational literature, dealing with contested issues such as racism, migration and citizenship itself, reports the combined and sometimes contradictory processes of globalisation, regionalisation and localisation (Peters et al., 2008).

In 1998, the Crick Report (QCA, 1998) identified three key concepts that underpin the study of citizenship: rights and responsibility; political and economic literacy; and encouragement of community involvement. However, none of these seem to be explicitly related to GCE. GCE, understood as Cosmopolitan Education, seems to be more interlinked with the number of projects of citizenship education that, according to Humes (2008) followed the Crick Report. In fact, Humes has argued that, in the educational literature and research following the Crick Report, the focus, on the three abovementioned key concepts, was “somewhat lost as debates about citizenship spilled over into many related fields” (2008: p.45). These fields, for instance, included anti-racist education (Osler, 2000); identity and diversity education (Gundara, 2000); intercultural education (Derricott, 2014); and moral education (Holden, 1998).

Taken together with other work on CE and GCE, such as rights and democracy education (Alderson, 2000), cosmopolitan justice education (Enslin and Tjiattas, 2004), gender education (Forde, 2008), patriotism in education (Papastephanou, 2008), ethnicity in citizenship education (Carrington and Menter, 2008) and environmental education (Walter, 2009), constitute a range of forms of CE. They develop a broader sense of citizenship that includes gender, ethnicity, location, faith or other factors. Some of these factors reinforce a local sense of citizenship, others weaken the traditional allegiances to a particular nation (Humes, 2008). Within these various interpretations of citizenship, GCE, in Europe, generally embodies the idea of extending the ideologies of human rights, multiculturalism, peace, justice and solidarity (Peters et al., 2008). However, there is “no one dominant notion of GCE as notions of ‘global’, ‘citizenship’ and ‘education’ are all contested and open to further argument and revision” (Peters et al., 2008: p.11). In this thesis, GCE is interpreted as Cosmopolitan Education.

The basis for western cosmopolitan thought was laid down thousands of years ago in Greece by philosophers who advocated the cosmopolitan aspects of human nature. The word cosmopolitan derives from the ancient Greek *kosmopolitês* which means ‘citizen of the world’. The Greek concept of cosmopolitanism was rooted in the Sophist critique to the political culture idealised by Plato and Aristotle, who advocated that a person identifies him or herself first and foremost as a citizen of a particular city (Kleingeld and Brown, 2014). In opposition, in the fifth century BC, Sophists sustained the ideal of an allegiance to humanity as a whole. Hippias, for instance, addressed a crew of Athenians and foreigners in the following way: “I regard you all as kinsmen, familiars, and fellow-citizens — by nature and not by convention; for like is by nature akin to like, while convention, which is a tyrant over human beings, forces many things contrary to nature” (Kleingeld and Brown, 2014).

In the late fifth century BC, these cosmopolitan ideals were embraced by Cynics, such as Diogenes, who rejected traditions and local loyalty (Appiah, 2008). Later, in the century that followed, these ideals were further developed by Stoics (Kleingeld and Brown, 2014). Contemporary notions of western cosmopolitanism derive from the Enlightenment idea that there is a single moral community. Such notions are not in contrast but rather in a creative dialogue with the issues of rights and responsibilities ascribed to people within the boundaries of a state. The cosmopolitan idea of a humanity belonging to a single moral community was defended and popularised by Kant and is currently echoed by issues relating to human rights and by the United Nations (Peters, Blee and Britton, 2008).

Scheffler (1999) maintains that contemporary conceptions of western cosmopolitanism either encompass principles about justice or principles about culture and the self. However, these two strands for viewing global citizenship are not mutually exclusive. The former is a form of cosmopolitanism that rejects the idea that the norms of justice can be properly applied only within cohesive human groups such as nations. This does not mean that cosmopolitans in this framework do not recognise nations or cultural traditions. In Appiah’s view, for instance, traditions matter not in themselves but because they matter to people and one cosmopolitan heritage from Diogenes is the commitment to care about all human beings. “Everybody matters: that is our central idea” (Appiah, 2008: p.96).

The key concept of this interpretation of cosmopolitanism is the universality of human rights. Appiah defines cosmopolitanism as “universality plus difference” (2008: p.94), that is, the legitimacy both of universality (of human rights) and of cultural differences. Therefore, cosmopolitanism is not a rejection of cultural diversity. In fact, Appiah states that, “one distinctively cosmopolitan commitment is to pluralism” (Appiah, 2008: p.96). From such a point of view, cosmopolitans challenge the global homogeneity sought by both religious and political fundamentalists.

A second heritage from Diogenes which is relevant to education, is the acknowledgement that good things can be borrowed from any society in the world and that dialogue is an essential requisite for human communication. Diogenes’ heritage today seems to be even more important. In fact, a necessary condition for making global citizenship a reality and not just an ideal, as it was at the time of Diogenes, is knowledge about the lives of other citizens and having the power to affect them (Appiah, 2008). Today the single web of trade, the global network of information, the possibility to sending something useful anywhere, the global media, radio, television, telephones and internet are making it possible to work together towards raising standards of living, for instance by adopting new policies on trade and aid and taking measures against global warming.

Therefore, a cosmopolitanism that encompasses principles about justice is the attempt to foster in students a cosmopolitan spirit, by conceiving education more broadly than simply as information learning. For such reasons, educators should foster an openness to others, openness to people and cultures beyond one’s own , because in fact, although one can be wrong about one thing, that does not mean that one cannot be right about another (Appiah, 2008). Appiah, for instance suggests cross-national educational projects: “encouraging young people to go abroad and work and study with young people in other nations, and inviting young people of the other nations to study here” (2008: p.92).

This way of conceiving global citizenship education seems informed by the contact hypothesis. The contact hypothesis was proposed by the social psychologist Gordon Allport and consists of the idea that when contact between people from different cultures happens between peers involved in an activity with shared goals, the result is that hostility and prejudice are less likely to occur. For example, Appiah (2008: p.92) maintains that military and basketball players seem to be less racist for reasons explained by the contact hypothesis. For the same reason, segregation of communities in our society and limiting the opportunities for children from different cultures to meet and collaborate on terms of equality for a common goal, may have disastrous consequences.

As I have mentioned previously, there is a second conception of western cosmopolitanism identified by Scheffler (1999). That is the form of cosmopolitanism that encompasses principles about culture and the self. Within this framework, the idea that the identity of individuals depends on their belonging to a given group of people who share elements of history, religion, ethnicity, culture or language is substantially rejected. The defenders of this view of cosmopolitanism, in fact, maintain that culture is constantly changing, updating and modifying because it is very rare that human populations live in isolation from each other. From such a point of view, giving special attention to one’s own family, religion, ethnicity or nationality is legitimate only if it is done with reference to an allegiance to humanity as a whole (Nussbaum, 1994). Therefore, global citizenship education consists not only of promoting the ability to consider individuals as citizens of the whole world, but also in promoting the ability to criticise one’s own traditions (Nussbaum, 1994).

Central to this educational thought is the promotion of the ability to imagine what it would be like to be in the position of someone else, for instance someone who is not part of one’s own family, religion, ethnicity or nationality (Nussbaum, 2002). With this aim in mind, Marta Nussbaum puts at the centre of her interpretation of global citizenship education the feeling of compassion which has to cross the line of time, place, nation and gender (Nussbaum, 2003). “Compassion is an emotion directed at another person’s suffering or lack of wellbeing” (Nussbaum, 2003: p.14). However, in order to make compassion real, we have to make the other somehow familiar. Therefore, in order to feel others’ vulnerability, terror and pity we must consider the others just like us. Only in this way can it be true that “they are just us […] we are the ones who suffer […] not those other ones” (Nussbaum, 2003: p.11). In line with this, Martha Nussbaum discourages, in education, the use of the polarising language of us versus them.

In the history of Western philosophy, two opposing views have influenced scholars regarding the possible role of compassion in promoting cosmopolitanism. From the first position, maintained by Euripides, Aristotle, Rousseau and Hume, among others, the promotion of compassion in citizens is the best way to foster in them allegiance within and across national boundaries. From the opposite position, sustained, for instance, by Plato, the Stoics, Spinoza and Adam Smith, compassion is a threat to the foundation of an unprejudiced world community. These thinkers, who believe that compassion is too impartial, invoke instead the ideas of dignity and respect in the attempt to foster cosmopolitan values (Nussbaum, 2003).

Martha Nussbaum argues for the former position. However, in cultivating compassion in schools, she admits that the feeling of compassion can fail and can even produce its opposite effect. For instance, she notices that the patriotic compassion for the suffering of victims of September 11 has resorted to the language of us versus them, in the so-called war on terror. As a consequence, political refugees escaping from misery and police repression are invited to go back their own countries. One problem with compassion, Nussbaum (2003) maintains, is that the suffering of people living on the other side of the world does not work up enough emotion in us sometimes even to prompt humanitarian intervention (e.g. the genocide in Rwanda). The deaths of thousands of people on the other side of the world may result in the expression of sorrow, but normally does not have any influence on our lives, which continue as if nothing has happened. In other words, the problem with compassion is that compassion is narrow and fails to include distant people. We can imagine the emotional sphere of a person as a series of concentric spheres, with the people for whom the person cares at the centre, and at the periphery those who are unknown and living on the opposite side of the world (Nussbaum, 2003).

A second problem with compassion arises from our tendency to polarise the world into “us and them” (Nussbaum, 2003). In such a way, the well-being of “their” nations and children is subordinate to “our” people and children. No matter if migrants are escaping from war, genocide, malnutrition, earthquakes, floods and death. Our problems come before “their” problems. Therefore, Nussbaum admits that distance and the polarisation in “us and them” risk making compassion a non-trustable moral sentimen in the cause of global citizenship education (Nussbaum, 2003). In addition, a further problem depends on the fact that compassion is closely related to social justice issues. For instance, those who think that it is right to deny women the right to vote cannot feel compassion for women who suffer for such social injustice. Similarly, those who think that it is right to eat meat and exploit non-human mammals cannot feel compassion for all the animals suffering because of the meat market and milk production.

Nussbaum (2003) points out that, to feel compassion, a number of assessments need to be made. First, the person can feel compassion if she or he assesses the reason of the suffering as a serious reason (i.e. not as a tantrum). Second, she or he should consider the person who is suffering as deserving of his or her compassion. Third, Nussbaum, after Aristotle and Rousseau, considers essential the judgement of similar possibilities. For instance, the suffering of parents for the loss of their children is easy to understand and share even when considering non-human animals. Finally, compassion requires that the people who are suffering are part of the emotional sphere of the person feeling compassion.

Therefore, in spite of her arguments to promote compassion in education Nussbaum admits that, to put it in her own words, compassion is slippery and uneven. In fact, the assessment of the seriousness of the lack of well-being of the person who is suffering risks being influenced by one's own subjective assumptions and interpretations of the world. For instance, people who have the idea that illegal citizens are first of all people who, substantially, are committing a crime by breaking the law, fail for that reason to have compassion for them. In short, compassion seems to be quite unreliable and this is the reason for other philosophers to search for a more perfect social motive.

The recognition of human dignity has been proposed by the Stoics and Cicero and on through Kant and beyond, as an alternative basic social motive. According to this countertradition, the recognition that every human being has dignity should promote moral obligations towards all humans, irrespective of nationality, gender, religion, social class and status. From this point of view, compatriots and foreigners, women and men, servants, princes and even enemies, in the light of their human dignity, become equal. In consideration of such a human dignity we are supposed to treat everybody as equal. Thus, not the compassion towards people we do not know anything about, but rather the recognition of their human dignity should be promoted in education and should regulate morals and politics and impose obligations for the well-being of all human beings.

The partisans of dignity maintain first that respect for dignity assures that all human beings are treated as equals. Compassion, they sustain, cannot do the same. In fact, as compassion stems from the circle of people we care about, compassion will rank people accordingly to the four boundaries I have previously discussed. Focusing on compassion, people will be ranked vertically because of ineluctable stronger and more enduring compassion we feel for the suffering of our relatives rather than for the victims of genocide on the other side of the globe. On the contrary, according to philosophers who argue in favour of the Stoic countertradition, focusing on the recognition of human dignity that is present in any person, we will rank people horizontally and we will have to recognise human dignity even in criminals. This takes us to the second point in favour to the proposal to foster in students the feeling of human dignity rather than compassion. That is the fact that we already follow this countertradition in other fields which differ from education. For instance, in Europe, the notion of human dignity is central to the law of punishment (Nussbaum, 2003).

Whitman (2003, cited in Nussbaum, 2003), in fact, maintains that contemporary American criminal punishment is more degrading than punishment in continental Europe. The scholar notes that degradation can play a significant role in punishment. The verb ‘to degrade’ means to reduce a person in status and thus to treat him or her as inferior. In short, Whitman maintains that the differences between American and continental prisons rests on the commitment in Europe to accord dignity to the prisoners, for instance through abolishing prison uniforms, protecting prisoners’ intimacy and involving them in jobs that are real jobs. While convicted people in the States are frequently deprived of civil rights, in France and Germany there are programmes intended to encourage inmates to exercise their right to vote. In summary, acknowledging dignity seems to be less bounded than compassion and it is already a practice in some fields other than education. It is present in international human rights documents and in European prison policy since the eighteenth century (Nussbaum, 2003).

Unlike Nussbaum, Appiah’s cosmopolitan thought is inherited from Stoic countertraditon ideals. Appiah justifies his cosmopolitan thought with the idea that every human being is provided with dignity because of his or her capacity for rationalisation which differentiates him or her from other animals. In fact, he admits that if the animals we kill for food shared our capacity for understanding and planning, the way we treat them would be a form of “speciesism” (Appiah, 1990: p.13) which would be as wrong as racism.

In other words, Appiah justifies our cruelty to animals with the greater richness of our mental capacity, which he sees as the base of human dignity. In his view, the universal concern of cosmopolitan is that every human being matters. This way of thinking coincides with the traditional Stoic point of view which excludes non-human animals because of their supposed lack of rationality. From this point of view, Appiah's conception of GCE is very different from those of Martha Nussbaum.

Nussbaum points out that the problem with the notion of human dignity lies in the fact that it "relies on the better-than-the-beasts idea" (Nussbaum, 2003: p.18). That is the idea that humanity is the best product of Nature and is at the top of a hierarchical ladder that goes from bacteria to our species. It is the idea that the worst of us is much better than any beast because of our reason, language and moral capacity. From such a point of view, dignity is something that humans have and but all the other living beings do not. Nussbaum argues against such a point of view, assuming that modern science shows a very different picture of Nature. Acknowledging human dignity as a basic social motive for cosmopolitan education is what Nussbaum calls "the animal problem", that is, the idea of human dignity is underpinned by the anthropocentric notion that lies in the dichotomy of human-animal.

This is the fundamental reason why Nussbaum puts compassion and its extension to education at the centre of her account for cosmopolitan citizenship. From such a point of view, educating for global citizenship has the main task of educating for compassion as best as we can. Aware of the places where compassion goes wrong because of its biases, teaches should promote the ability to move back and forth between the perspective of our personal cares and the perspective of the distant. Aware of the risk of making errors of fault, seriousness, and the circle of concern, in educating for compassion educators are called upon to develop imaginative and emotional understanding of what our choices mean for people in different circumstances, and to highlight how aggressive local loyalties and attachments are against a more general empathy.

In addition, Nussbaum warns against promoting in education the ideas of self-sufficiency, control and domination. She suggests that such notions promote emotional illiteracy which results in a lack of understanding of the weakness that all humans share. In contrast, she proposes the education of weakness and vulnerability in which, through stories and dramas, students should be able to understand the suffering of others, including distant humans and animals. In fact, central to Nussbaum's global citizenship education is the promotion of narrative imagination which is the capacity to identify oneself with someone very different from oneself (Nussbaum, 2002).

Therefore, the two modern educational philosophers I have considered differ in their account of GCE as a biological issue. Nussbaum considers worth trying to cultivate a Sophist compassion in young people in order to educate for global citizenship. In this way, she also includes within the cosmopolitans the defenders of animal rights. Without this capacity for sympathetic imagination it is not possible to feel the "pain of the whole animal world" (Hesse, 1980: p.8). In contrast, Appiah advocates for human dignity and seems to support the view that non-human animals are very different from us. However, both Appiah and Nussbaum belong to strands of global citizenship education which are underpinned by the cosmopolitan features of universality and generality, which in turn consist of the belief that there are universal laws and knowledge that can be generalised, rather than only applied to unique individual social contexts (Pogge, 2002).

However, GCE may have many meanings because there are many and sometimes contradictory and contested interpretations of global citizenship itself (Tully, 2008). Tully maintains that most of these many interpretations of global citizenship can be substantially clustered in two practices that he defines as *modern* and *diverse* global citizenship (2008). *Modern global citizenship* consists, substantially, in the project to extend the form of citizenship characteristic of the western tradition of modern nation states. This notion of citizenship stems from the political philosophical concept of *social contract* elaborated by Hobbes, Locke and Rousseau (Peters, Blee and Britton, 2008). In short, the social contract consists of the intentional sacrifice of one's own potentially unlimited natural freedom in the name of the common good and collective security. This results in a formal legal order that is the constitutional rule of law. Outside this order we find nature, the realm of uncivilised, the war of all against all (Tully, 2008).

In this tradition, citizenship requires a formal legal order, a representative government that consists of a status given from above. From such a point of view, global citizenship is a status which can be given or not given to a person, according to national and international laws justified by the historical development of four tiers of rights and duties: civil liberties, civil rights, socio-economical rights, and minority rights (Tully, 2008). Civil liberties include freedom of speech, faith and thought, market freedom and free trade. Civil rights are democratic liberties which include, among others, free participation in the representative government, freedom of the press, the rights to vote, join parties and non-governmental organisations, to stand for election, and to demonstrate in the public sphere. The third tier of rights consists of the minimum social and economic conditions indispensable for a citizen to exercise their civil liberties and their civil rights. The forth tier of rights consists of the rights of minorities to be protected and integrated into modern forms of citizenship.

Modern civil citizenship is the predominant form of global citizenship because it is promoted by the Euro-American hegemony (Tully, 2008). It is presented as a universal model for all human societies. In this sense it is cosmopolitan. However, this cosmopolitan meaning cannot be completely superimposed on that of the Sophist meaning of the term. From a sophist point of view, borders are human conventions which impede the realisation of one human global society where everyone is a citizen of the world. On the contrary, within the modern framework, citizenship, being a status given from above, it is not for every human of the world. In addition, nations in the form of Western modern states are the universal and legitimate forms of authority under international law. They are considered the product of an historical process of progress through civilisation, modernisation, constitutionalisation, democratisation and globalisation (Tully, 2008).

As I mentioned earlier, other meanings of global citizenship are clustered with the term *diverse* which Tully defines as “the global networking of local practices of civic citizenship” (2008: p.16). Diverse global citizenship, rather than being a status given from above and underpinned by an historical process of progress desirable for all human societies, is an integrated assemblage of a myriad of place-based practices of citizenship which consist of the local, civic and democratic participation of people in their local community. Therefore, rather than a status given by a recognised institution, diverse global citizenship depends firstly on the active civic participation of a person.

The citizen is a civic actor or actress in a local context. Unlike modern citizenship, it is not a universal form of citizenship valid for any human society. Rather, it is the process of a multiplicity of practices of citizenship in mutual dialogue amongst each other. Citizens, rather than being bearers of civil rights, are people who have the abilities and the competence for civic participation in society. From this point of view, citizenship does not consistof an institutional status, but of the cooperative relationship among citizens and in the competitive relationship between citizens and governors. Fellow citizens organised in democratic organisations call into question those institutions and negotiate with the government in their activity of caring for the public, the community and the civic good. Example of practices of worldwide diverse global citizenship are, for instance, the counter-hegemonic citizen networks related to fair trade, organic farmers, low-cost housing, anti-racism associations, nongovernmental organizations, animal rights activists, place-based cultural associations and the ethnic minority communities which struggle for their diverse forms of citizenship in modern citizenship institutions.

2.3 The interplay between school science and citizenship education

The relationship between school science and citizenship education has a long history. In this section I first provide a brief historical account and, secondly, discuss findings from literature investigating teachers’ perspectives in dealing with scientific issues that clearly also have ethical, controversial and citizenship facets. Finally, I illustrate the theoretical frameworks in which teachers and scholars operate in their attempt to make school science relevant for students' active participation in society.

2.3.1 An historical account of the relationship between school science and citizenship education

Contemporary societies are hugely influenced by science and technology. Citizens are constantly expected to take up positions on issues (e.g. stem cell research, genetic engineering) with conceptual or technological links to biology and science. As these issues, beyond affecting citizens' lives, are informing contemporary norms, a number of scholars advocate that responsible citizenship in contemporary societies demands some sort of scientific literacy (Davies, 2004).

In this chapter, I describe the main frameworks of the international educational research that in the twentieth and twenty-first centuries have been guided by the purpose of engaging school science with citizenship education. Over a century, school science has moved from a content-led subject to the contemporary school science which aims at fostering the understanding of the nature of science by recognising the social, technological and ethical aspects of science. This process developed mainly through two phases, the so-called Science and Technology Society movement and the Socioscientific Issues movement (Jenkins, 2006).

In the history of western education there have been a number of attempts to make school science education an essential element of citizenship education. The first explicit attempt dates back to the early twentieth century and was a consequence of the moral implications of the role that science with chemistry played in the First World War (Jenkins, 2006). During the 1930s, interest in teaching biology topics at school increased precisely in order to contribute to citizenship education. In fact, biological literacy was considered a possible means for illuminatinga range of social health problems related to hygiene. In those years, the Social Relations of Science movement was promoted by the work of Lancelot Hogben and others (Jenkins, 2006). Hogben maintained that school biology courses had to reflect personal and social needs, rather than exclusively the needs of those students oriented towards scientific academic studies. His position was supported by the botanist, Brimble, (Jenkins, 1979) who argued that principles of social biology should be included in school curricula because they were regarded as the basis of problems related to ‘individual and public health, nutritional standards, housing, population movements, race and nation, problems of family life, relations and responsibilities of one person to another, social policy of the State’ (p.70).

After the Second World War, the trend of engaging biology education with the concerns of citizenship tended to fade. In fact, the enormous success of biochemical and crystallographic studies of cells shifted biology curricula once again towards the academic aspects of science (Jenkins, 1980). However, in the second half of the twentieth century, the ethical, political, economic and environmental issues relating, in particular, to pollution and energy resources, made the perception of science less neutral (Redner, 1987). In fact, if the developments in science had brought untold benefits, they carried also anxieties and fears about new hazards due to nuclear technologies, chemical treatments of the soils, monoculture crops, high voltage transmission lines, greenhouse gas production and genetic engineering, amongst others (Levinson, 2010). In addition, the end of the post-war boom, the increasing globalisation and the need for sustainability made very narrow the line between academic science and industrial science, making academia increasingly subject to market and business forces (Levinson, 2010). As a consequence, the view of science as a system of knowledge production driven by reason was called into question and the generation and validation of scientific knowledge became inseparable from the social context of its application (Nowotny et al., 2001).

The Science-Technology-Society movement (STS) originated in this context with the purpose of re-engaging school science with citizenship education (Jenkins, 2006). Despite its diverse and complex origins, the STS movement conveyed the idea of socially constructed knowledge and demanded the reform of science curricula in order to make science more meaningful to students, in particular by integrating the basic facts, skills and concepts of traditional science into the social and technological context of citizens' lives (Aikenhead, 2006). Curriculum initiatives related to the STS movement increased under the influences of both national (e.g. in the UK's Association for Science Education) and international organisations (e.g. UNESCO, the International Council of Scientific Unions, ICSU, and the International Organisation for Science and Technology Education: IOSTE). By the end of the 1980s, the need to promote a better public understanding of science became part of the political agenda in many countries, and the educational purpose of school science to promote informed citizenship became widely accepted (Jenkins, 2006).

However, Pedretti and Hodson (1995) argued that STS education resulted often in marginalising social dilemmas and controversies in ancillary text boxes in science textbooks. This critique was also voiced by Hughes (2000) who pointed out that, in school STS approaches, the socio-scientific dilemmas were the icing on the cake rather than an essential ingredient. In addition, Zeidler et al. (2005) maintained that the STS movement failed to adequately address student conceptions of the nature of science. Furthermore, findings of pedagogical research suggested that there were problems in the public understanding of science and that, in some cases, scientific knowledge was ignored because it was believed irrelevant and weighted compared to other elements, such as personal beliefs, religion, values and ideology.

The emerging view of science was a field of uncertainty, contentiousness and lack of confidence, rather than a coherent and objective way of knowing (Jenkins, 1999). For instance, biotechnologies like genomics, genetic manipulation and the use of embryos in stem cell research resulted in high uncertainties and in increasing tensions between scientists and non-experts. In addition, those areas where there were conflicts in values between those who emphasised the benefits to human health and those who highlighted the potential damages, had the obvious feature of being multidisciplinary, linking scientists, consultants, lawyers, statisticians and technicians. Uncertainties and this multidisciplinary nature marked “a transformation from Enlightenment science – value-free, objective and impersonal – to one imbued with values, diverse subjectivities and integrating multi-party perspectives” (Levinson, 2010: p.77). From this scenario, the current main international research in science education emerged, the so-called Socio-Scientific Issues movement (SSI).

Within the SSI framework, citizenship education is carried out in the science classroom through teaching socioscientific issues, namely, complex issues with their bases in science that interact with students’ values and are objects of controversy and media interest. They are, for instance, those related to stem cell research, genetic engineering, cloning, genetically modified foods, environmental problems, biomedical research, animal rights, and issues that involve the need for individual choice in the face of conflicting or incomplete information (Grace, 2006). For these characteristics, the role of science teachers dealing with socioscientific issues in the classroom is mainly to highlight the nature of science (NOS), that is to highlight different aspects related to science such as the ontology and epistemology of science, the essential character of science, how science works, how scientists behave as social groups and how society influences science (Clough and Olson, 2008).

Therefore, the SSI movement promotes a school science that does not consist merely of developing the ability to evaluate the validity and reliability of data in order to distinguish between facts and opinions. Rather, the ability to distinguish between facts and opinions is seen as a controversial issue in itself. Zeidler et al. (2005), for instance, maintain that the ability to evaluate neutral evidence is not an easy task in a reality where collective decisions are driven by the joint construction of social knowledge. This does not mean to disallow the traditional key purpose of school science of developing the habits of mind consisting in scepticism, open-mindedness, critical thinking, acknowledgement of ambiguity and of data-driven knowledge. However, educating for citizenship through teaching socioscientific issues implies the application of such habits of mind to science itself (Zeidler et al., 2005). The SSI framework drives towards reform initiatives that might develop an understanding of scientific inquiry as a possible way of knowing and a functional scientific literacy committed to the ethical dimension of science education and the social and psychological development of students (Zeidler and Keefer, 2003).

The international trend of research in science education, embodied by the SSI movement, aims at explicitly developing psychological, ethical and epistemological aspects of the students' learning and at enabling them to develop their own opinions rather than providing them with scientific truths. From this point of view, SSI approaches improve on those of the STS movement by introducing students' personal beliefs as a critical variable in the pedagogical effort to make interconnections among science, technology, society and environment (Zeidler et al., 2005). Therefore, it seems reasonable that one important aim of school science is to provide students with the functional scientific literacy necessary for active participation in society. Cross and Price (1996), for instance, maintain that science education should prepare future citizens for participation in resolving controversial scientific issues.

In the following section, I consider this educational issue by providing firstly the teachers' perspectives on it and secondly the theoretical frameworks in which they operate in their attempts to make school science meaningful to the democratic participation of citizens in the controversial scientific debates of contemporary societies.

2.3.2 School Science for the democratic participation of citizens in socio-scientific debates

In contemporary European schools, there are therefore forces that drive towards science curricula initiatives that aim at educating students for and through democratic citizenship to participate in the debates raised by the advances in science. Indeed, the aim of educating scientifically literate students for their democratic participation in society is seemingly uncontentious (Levinson, 2010). All the actors in education, from teachers to scholars and policymakers, seem to agree that scientifically literate citizens are in a better position to participate in the political and ethical debates surroundings complex biological issues such as genetically modified foods and embryo research.

Such an educational aim is even more crucial in contemporary societies in which scientific misconceptions can be easily spread out by social media and populist politicians. A case in point is the responsibility of media in giving relevance to the opinion advanced in 1998 by the now discredited Andrew Wakefield, the doctor who hypothesised a causal relationship between the MMR vaccine and autism (Godlee et al., 2011). Therefore, it is not difficult to understand the reason why, in school curricula, scientific literacy has become an international educational slogan with the stated purpose ofpreparing students to participate in today's world (Hurd, 1998; Laugksch, 2000).

However, a realistic informed participation in a range of socioscientific issues requires knowledge of the technical details of a high degree of complexity the kind that would make the science syllabus too unwieldy. In addition, the intertwined social, economic, political and ethical aspects of most socioscientifically contentious issues deepen what democratic participation in science can realistically mean (Levinson, 2010). The result is that teachers in some cases perceive constraints in teaching SSI, constraints that range from a lack of time to the critique to scientific knowledge itself (Grace, 2006).

It has been argued that the success of the implementation of citizenship education depends in part on how well-prepared teachers are for teaching controversial issues (Oulton et al., 2004). In addition, educational research documents significant relationships netween teachers' beliefs, teaching practice and student learning experiences (Bryan and Atwater, 2002; Sadler et al., 2006).

Therefore, the above-mentioned constraints may represent problems regarding what teachers think about their own proficiency in delivering biology classes with SSI approaches.

Part of these constraints stem from their associations with ethical considerations. In fact, several studies across a variety of schools and issues report that ethical concerns are among the most important factors in determining patterns of reasoning regarding SSI (Sadler and Zeidler, 2004). For instance, being value laden, SSI can be uncomfortable for teachers who define science in term of objectivity (Sadler et al., 2006). Studies that have investigated teachers' perspectives on dealing with controversial issues in science classrooms reveal a variety of attitudes.

Mitchener and Anderson (1987), investigating teachers' conceptions about using controversial issues, identifies three different teachers' profiles: educators who are concerned for the lack of time; educators who explicitly resist approaches involving controversial issues, believing that they are more linked to school social studies, rather than school science; and educators who are willing to use these approaches for connecting science to students' lives. Similar trends are revealed by Lumpe et al. (1998) whose study also highlights also a lack of appropriate resources and training among the constraints. McGinnis and Simmons (1998) show that teachers sometimes exclude the most overtly value-laden topics in favour of environmental problems because they are believed to be less likely to be perceived as controversial and are therefore easier to cover. Sadler et al. (2006) illustrate similar patterns relative to teachers' perspectives in dealing with ethical and controversial issues in science classrooms. These include respectively, conceptions of educators committed to teaching SSI; educators who are not; educators who are committed in theory, but who reports constraints for their actualisation; educators who believe that science is a value-free system of knowledge production; and finally, educators who believe in an integrated school curriculum where science, among other subjects, contributes to the ethical development of students.

In a study conducted in Scotland, where the national curriculum explicitly requires science teachers to cover social and ethical aspects of science, Bryce and Gray (2004) illustrate that teachers tend to marginalise the social aspects of SSI approaches because of the pressure of high stakes testing. In addition, Bryce and Gray point out that teacher training represents a serious impediment for the implementation of SSI approaches because it is failing to provide teachers with specific skills for structuring and leading classroom discussions.

Therefore, many teachers report that debates and discussions in the classroom on SSI can be difficult tasks (Grace, 2006). Oulton et al. (2004) maintain that the teaching of SSI is itself controversial and that many teachers are underprepared and feel constrained in their ability to handle the introduction of controversial issues in the science classroom. A survey (Oulton et al., 2004), that involved 205 science and geography teachers working in London, illustrates that 70% of the participants did not received formal training for dealing with SSI; 36% delivered lessons about controversial issues less than once a term; and that 71% felt that their school did not offer clear guidance.

In summary, teachers manifest concern first of all with respect to lack of time. Dense and demanding science specifications and the pressure to get good exam results make it very difficult to find the time to promote considerations of social and ethical issues. In addition, while teaching resources and activities for science contents are routine, resources for treating socioscientific issues are incomplete or inadequate (Grace, 2006). This results in teachers manifesting a lack of proficiency in using educational strategies to cope with controversial issues, and a lack of confidence in explicating personal opinion in teaching controversial topics (Cross and price, 1996) and in dealing with issues with no right answers (Grace, 2006).

Moreover, while discussions and debates about some socioscientific issues, such as genetically modified food, are acceptable in any schools, others such as the morality of abortion can be perceived by teachers as raising complex problems especially in some educational settings (Grace, 2006). In addition, Oulton et al. (2004) point out that while with some socioscientific issues, such as factory farming, it is recommended not to try to influence students to adopt a particular attitude, with other issues, such as racism, teachers are expected to present a biased view and to make their opinion clear to students.

A further educational issue resides in the fact that while the importance of encouraging students to articulate ideas and to engage in self-reflection is recognised, science teachers are not familiar with class discussion and struggle with making discussions successful and useful (Grace, 2006). For instance, in a study that involved seven average London schools, Newton et al. (1999) report little evidence of student discussions during science lessons. In addition, science teachers are reported to experience a lack of confidence in structuring arguments in the classroom (Driver et al., 2000) and, for disciplinary reasons, have concerns about the possible degeneration of discussions (Newton et al., 1999).

In dealing with SSI in the classroom, there are substantially two main scenarios. In the first, students are asked to weigh the risks and benefits of the application of science, such as the use of nuclear power or herbicides, where the scientific evidence is not in question. In these cases, the object of debates is the interactions of scientific application with ethical, political and economic aspects. By contrast, in the second scenario, the scientific evidence itself is the object of controversy. Discussions on global warming are a case in point. In the last few years, in many European countries, social debates on vaccines are another clear example. In these two examples, in fact, diverse groups advocate conflicting explanations on the values and reliability of the scientific evidence. In these cases, science itself becomes a controversial SSI and, critically, its objectivity is called into question.

Levinson (2010) illustrates that the attempt to bring value-related and ethical matters into the science remit can be framed in four different explanatory frameworks by which teachers, educators and scholars justify their attempts to make school science relevant for the promotion of the democratic participation of students as young citizens, in the scientific debates in our societies. These are: the *deficit*, the *dialogical* (or *deliberative democracy*), the *science education as praxis* and the *science education for conflict and dissent* frameworks.

In society, SSI raises public concern about science and technology. For instance, the word ‘cloning’ was already evoking negative significance in the late 1970s when cloning was much more limited than nowadays. In response to such citizens’ anxieties, governments and corporations put greater emphasis on public participation in decision-making about health and bio-technologies. The term *deficit* in the first framework refers to what citizens and students need to know in order to evaluate the opportunities and constraints of science and technology and, possibly, in order to support government and corporate funding (Levinson, 2010).

The deficit framework assumes “scientific sufficiency and public deficiency” (Gross, 1994: p.6). Within this framework, biology teachers, in dealing with disputed research issues such as cloning and the use of embryos or animal in experimentation, inform the students about the medical purposes and the societal benefits of these technologies. The motivation behind the deficit approach is underpinned by the belief that the problems posed by the SSI are predominantly technical. Therefore, science curricula have to redress problems that consist substantially in any lack of knowledge that might limit democratic participation.

However, within the deficit framework, school science is not believed to provide students with the expertise to comprehend the technicalities of the contemporary SSI. “Within the deficit framework, a scientifically literate person would know some science as well as something about methods and procedures, applications of science and role in society” (Hazen & Trefil, 1991, cited in

Levinson, 2010: p.80). Within this way of understanding the role of school science for citizenship, teachers must select approaches appropriate to the students' cognitive level of development. However, rather than providing students with high levels of scientific knowledge, they are supposed to foster students' trust in science. They have to provide students with some insights into the complexities that stakeholders have to consider in making decisions related to socioscientific issues.

Within the deficit framework, science is a corpus of universal knowledge that remains unchanged by the social changes around it (Levinson, 2010). The knowledge resides in experts and can move towards students through the sensitive work of science teachers. At the best, educators are requested to develop in students a competence in gaining access to relevant knowledge for decision-making. Decision-making on SSI is influenced by the field in which science is applied. In other words, one thing is animal experimentation for medical purposes; another is the use of animals with the final aim of developing biological weapons. However, students are unlikely to be expected to develop expertise for competent decisions about such complex SSIs, but instead to trust in science and the experts when they become aware of the level of technical complexity.

However, Irwin (2001) argues that the public disquiet over environmental and food safety and genetically modified organisms has raised issues in the relationship between science and citizenship education. For instance, in the UK, during the late 1990s, the assessment of the relationsship between science and the public was quite negative, and public concerns over uncertain fields of science were "arrogantly dismissed as irrational and emotional" (Irwin, 2001: p.2). This was followed by a significant period of review and reassessment in terms of the way the UK government system was handling the relationship between scientific developments and public concerns. In addition, academic research advanced the acknowledgment of the fundamental nature of scientific uncertainty, the significance of public trust and the need to move beyond the deficit model in describing public responses. As a consequence, greater public dialogue and engagement resulted in "a newly *harmonious relationship* between UK policy processes and social scientific research, and of a much *greater degree of openness* to public evaluations" (Irwin, 2001: p.2).

At present, in the contemporary justifications for the reforms on citizenship and science in school, the *dialogic* mode of understanding the need for scientific literacy is an alternative to the *deficit* mode (Miller, 2001). Within the dialogical framework, also called deliberative or contextual, citizens are differentiated into groups that are supposed to participate in deliberative dialogues with each other and with scientists, in order to address context-related problems. Through such deliberative dialogues, scientific knowledge can be remodelled to address problems (Levinson, 2010).

In the classroom context, scientific knowledge comes from scientists. Teachers, by emphasising critical thinking and understanding of the scientific methods, may dialogically work with students, remodelling scientific knowledge. The dialogues are used to reveal contradictions, to clarify understandings and to help students to construct fundamental scientific concepts (Chin, 2007). Dialogues, although mediated by power relationships and institutional contexts, are central and necessary to learning scientific concepts (Lemke, 2001). Moreover, dialogues induce students to think about socioscientific issues and promotes listening and speaking in classrooms about techno scientific issues (Levinson, 2010).

In addition, within the deliberative framework, dialogues, beyond being understood as a means in the collaborative construction of knowledge, are also associated with communicating across socio-cultural differences and deliberative democracies. A deliberative democracy is one in which equal citizens supply reasons and divergent views to solve a problem (Levinson, 2010). This modus operandi "sees the generation of new public knowledge about science much more as a dialogue in which, while scientists may have scientific facts at their disposal, the members of the public concerned have local knowledge and an understanding of, and personal interest in, the problem to be solved" (Miller, 2001: p.117).

What is presupposed in this framework is that all participants are free, equal and reasonable people committed towards finding a consensus. However, it has been argued that in school, as well as in the wider society, the conditions of freedom and equality cannot be assumed because of the inequitable distribution of power and cultural capital that leave groups of citizens marginalised (Ellsworth, 1989). Therefore, differences cannot necessarily be solved through dialogues because there are different criteria of rationality.

A further critique is that beyond the rhetoric underpinning this framework, the dialogic model has a deficient core. In fact, the agenda of the dialogue is driven by the knowledge producers who are also those who, at the end of the day, make the decisions. In other words, the dialogue is authentic, but the decision-making results are ineffective from the point of view of the lay participants, and the balance of power remains with those who drive policy (Levinson, 2010). Therefore, in both the deficit and the deliberative frameworks, democratic participation is limited because citizens have no role in planning the agenda. In fact, even within the deliberative framework where there is empowerment because citizens and students participate in a deliberative dialogue, their role is reactive rather than proactive and they have a limited or no role in the decision-making (Levinson, 2010).

The two other alternative frameworks for learning science for citizenship participation arise from the critique of the forms of science and technology at the service of corporate business that have generated social and environmental degradation. Steven Rose's critique of contemporary biology is illustrative: "from its Baconian inception, modern science has been about knowledge and power, above all the power to control and dominate nature, including human nature" (Rose, 1998, cited in Levinson, 2010: p.97). From such a point of view, school science, as it is within both the deficit and the deliberative frameworks, is interpreted as a form of indoctrination of students.

Scholars and educators within the *science education as praxis* framework question the relevance of what is taught and learnt in school science classrooms to what is experienced by most individuals in society. For instance, when investigating the level of scientific literacy of the population, people are tested on their knowledge of scientific facts, such as the inefficacity of antibiotics on viruses and the shorter distance of the Sun in winter compared to summer (Miller, 1983). However, scholars in the *science education as praxis* framework argue that the ability to accurately report abstract scientific knowledge is of little use in understanding how decisions are made within a local or bigger community and thus it is of little use for active participation in society. Therefore, the value for citizenship of a scientific literacy consisting of the knowledge produced by scientists is called into question (Layton, 1991).

Within this framework, students are involved in campaigns for justice and environmental sustainability in their local community and, starting with the scientific knowledge useful for what needs to be done, construct social knowledge, involving agents, such as environmental campaigners, residents, farmers and scientists, with different motivations, interests and concerns. In this way, school science is integrated within a larger communal purpose, such as cleaning up a polluted creek in their area (Roth and Lee, 2002). School science is a resource among others for solving a shared problem. The scientific knowledge is contextualised and emerges as collective learning, resulting in a collaborative action. The significant features of this way of learning science for citizenship are interdisciplinarity, co-construction of knowledge and common purpose (Levinson, 2010).

Although more radical, the science education as praxis model is based, like the deficit and the deliberative frameworks, on the premise that democratic participation is happening within existing democratic institutional structures, such as parliaments and schools. Like the other two models, science education as praxis also remains broadly within what can be called a deliberative Rawlsian approach to citizenship education (Ruitenberg, 2009). That is a kind of citizenship education that is underpinned by the presumption that consensus about differences can be attained through dialogue between reasonable persons (Levinson, 2010).

Otherwise, the more radical scholars, educators and teachers within the *science education for conflict and dissent* framework have as their main educational aim the disclosure of the possible causes of social injustice which underpin a dominant scientific knowledge in society (Levinson, 2010). They question some of the core tenets of the deliberative model of citizenship education on account of the fact that those who have political hegemony can easily set the terms of the debate. Furthermore, they argue for the ineradicability of antagonism and the impossibility of achieving a fully inclusive rational consensus (Mouffe, 2000).

Within this framework, Ruitenberg argues that educating for political emotions would require that students develop “a sense of solidarity and the ability to feel anger on behalf of injustices committed against those in the less powerful social conditions rather than on behalf of one’s own pride” (2009: p.7). Ruitenberg advocates for the need to explicitly teach students how power operates and how terms of discourse are imbued with hegemonic assumptions. Otherwise, keeping politics out of a scientific issue results in the acceptance of the status quo.

In addition, in circumstances of social injustice or social exclusion, for instance, democratic debates among reasonable contending parties may not be seen as an option. In fact, “where reasonableness and calm are seen as the virtues in liberal formulations of deliberative dialogue, feelings of outrage and injustice can become a barrier and exclusionary” (Levinson, 2010: p.104). Part of the global community is excluded from any forum of deliberative democracy. The people who suffered the leak of methyl isocyanate in Bhopal are examples of people whose voices went unheard for different reasons (Levinson, 2010). Urban students from high-poverty or ethnic minority backgrounds may experience lack of access to opportunities to learn science (Barton, 2002). The so-called illegal immigrants, illegal workers and sex slaves do not have any chance to participate in the deliberative forums on socioscientific issues. In addition, dialogue is possible where there are nuclei of agreement, but not where there are incommensurate differences in the point of views or in the historical tradition.

For instance, I have previously mentioned the contextualisation of school science in the project to clean up a polluted creek, in order to show an example of the integration of school science within a larger communal purpose. This project involved students, teachers, environmental campaigners, local residents, farmers and scientists, all with different motivations, but all involved in building knowledge and achieving change (Roth and Désautels, 2004). However, within such a case of science education as praxis, Roth and Lee (2002) also reveal tensions and a lack of dialogue within this First Nation community. Levinson (2010) argues that the problem might have risen from the fact that the dialogue among culturally dominant groups failed to take into account the views of the indigenous people.

The main pedagogical implication of the *science education for conflict and dissent* framework is the development of political literacy at school. For instance, in his critique of the dialogical framework in which citizens are supposed to participate in deliberative dialogues with each other and with scientists, Irwin (2001) wonders if public knowledge is given the same status as scientific knowledge, or whether, instead, the deficit model, which sees the public as uninformed and misconceiving, is recycled. Moreover, he asks who decides what is legitimate for public discussion and what is not; where is the balance in the process of giving information to the public and gathering information from them; what is the government response to public opposition to government policy; and, finally, what are the arguments concerning the special character of science, which requires highly specialised knowledge, in public discussion.

Bencze and Alsop (2009) suggest that science teachers should highlight in their classroom how “fields of professional science often serve as mechanisms for production, marketing and distribution of goods and services on behalf of business and industry and […] [how] science education generates various classes of lower-skilled workers and, perhaps, crucially, a societal mind-set geared towards unquestioning and enthusiastic production and consumption of for-profit goods and services” (p.2). Dos Santos, (2009) argues for a political goal in science education and advocates for a Freirean perspective of scientific literacy, which implies the establishment of a dialogical process in classrooms for the development of socio-political action and the promotion of a radical view that highlights the contradictions of science in society and the unequal distribution of the benefits of biotechnologies and globalization.

Within the *science education for conflict and dissent* framework, concepts of *biological citizens* (Rose, 2007) are conceptualised as dissenting collective identities who campaign for rights related to socioscientific issues. These concepts are underpinned by the idea of belonging to a group because of a shared biological feature (Rose, 2007). This sense of belonging may play a role in the construction of young people’s identity as future citizens. The *Education for All* Swann Report (1985), a report by the Committee of Enquiry into the Education of Children from Ethnic Minority Groups, defined a concept very similar, in the following way: “by birth, choice or chance we are all members of a variety of different 'groups', the members of which share characteristics which distinguish them from other groups. Our 'membership' of particular groups may be based on characteristics, such as age or gender, which are easily perceived and over which we have no control. […] It would be naïve in our opinion to deny the crucial role which ethnicity, perhaps particularly in the 'eye of the beholder', can play in determining an individual's place in this society” (p.4).

In this genomics era, the term biological citizenship has a variety of different meanings. Rose and Novas (2004) use the term “descriptively, to encompass all those citizenship projects that have linked their conceptions of citizens to beliefs about the biological existence of human beings, as individuals, as families and lineages, as communities, as population and races, and as a species" (p.2). Like other dimensions of citizenship, biological citizenship is transforming at national, local and transnational dimensions. "Inevitably, in discussing these issues, the spectre of racialised national politics, eugenics and racial hygiene is summoned from its sleep" (p.2).

Rose (2007) maintains that biological citizenship is related to the fact that citizens can now test themselves at the molecular levels and interact with other people based on knowledge produced by biomedicine, genomics and biotechnologies. It can be seen as a means for taking control of our lives, but it is, anyway, a new way of relating to each other based on genetics and molecular biology. For instance, people with a genetic disease can join together for comforting each other, helping each other, campaigning for greater knowledge in society, for funding research, and for creating an Internet virtual community for avoiding social oblivion. These new abilities of people to create communities based on genes, biology and molecular biology is seen by some as a means for breaking down the artificial barriers of nation and of the invented category of race.

Therefore, the concept of biological citizenship may have a positive valence in the democratic processes of a society as the creation of a community of people around a biological feature (e.g. HIV-positive status) and may be essential for combating stigma, for campaigning for human rights and for contesting unequal distributions of power. The biological citizenship reported by Adriana Petryna (2013, cited in Rose 2007), consisting in citizens who suffered the radiation effects of the nuclear explosion at the Chernobyl reactor and who made demands for particular social welfare and medical protection, is a case in point. A further instance is represented by the liberatory feminist pedagogues who, consider women an oppressed group and are concerned with why gender or other cultural or biological minorities are underrepresented in public arenas of society and encourage students to confront such inequities (Maher, 1987).

However, the concept of biological citizenship may also run the opposite risk of activating stigmatising and discriminating ideas about biological difference among communities of people or human populations. For instance, in the history of humanity, concepts related to biological citizenship have played an important role in naturalising misconceptions of human variation as the basis for social customs that make some individual citizens more valuable than others. In history, from South Africa (e.g. Apartheid) to Italy (e.g. fascist racist laws), from German (racial policy of Nazi Germany) and United States (e.g. anti-miscegenation laws), there are several examples in which supposed human biological diversity played a significant role in citizenship issues and in constructing biological citizenship. As a matter of fact, “historically humans have been discriminated against, divided, enslaved, expelled, disowned, endowed and praised, all on the basis of their biology” (Rose, 2007: p.1). Indeed, at least one strand of the racist doctrines is based on racialism (Tanguieff, 1999; Appiah, 2008), that is, the construction of a biological category of citizens based on the acknowledgement that there are genetic characteristics that allow us to divide our species into races and that the people belonging to such races share certain traits and tendencies which constitute a sort of racial essence (Appiah, 1990).

Appiah points out that the construction of racial biological citizens is based on the idea that differences in morphology are correlated with intellectual and moral capacity and that such a hypothesis is unbearable from a scientific point of view. “The truth is that there are no races, there is nothing in the world that can do all we ask race to do for us” (Appiah, 1985: p.35). However, Appiah warns biology educators about the fact that there are a number of people who, in spite of showing sometimes even great mental ability in some fields, seem to show a sort of “cognitive incapacity” (1990: p.7) which consists of their refusal to accept the scientific evidence against their beliefs on “races”.

The construction of biological citizenship based on the pigmentation of the skin is a case in point. On the basis of the distinction between white and non-white people, we might assume, for instance, that the differences between Europeans and Indians must be large. However, the genes responsible for external body features, which are generally used to demarcate the so-called races and ethnic groups, are highly influenced by climate. Hence, the use of these features in studying genetic history may be misleading because they disclose biological characters related to the geography of climates in which the population lived in the last millennia, and little about the phylogenetic history of a population (Cavalli-Sforza and Cavalli-Sforza, 1995). For instance, the so-called Caucasian race (e.g. European, Arabs) includes fair-skinned people. However, Caucasians such as southern Indians, living in tropical areas, have dark skin although their facial and body traits are similar to Caucasian Europeans.

The social construction of biological citizens and identities is possible only at the price of biologising what is culture or ideology (Rose and Novas, 2004). The consequence is that the intersection of race and gender and their interplay with biology, politics and big business concur at the resurgence of the biologisation and molecularization of citizenship to preserve the status quo of inequalities (Roberts, 2008; Fujimura, 2015; McGonigle and Benjamin, 2016).

The long history of the attempts to biologise genders is a case in point. Broca argued that "we must not forget that women are, on the average, a little less intelligent than men, a difference which we should not exaggerate but which is, nonetheless, real. We are therefore permitted to suppose that the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority" (1861, cited in Gould, 1996: p. 136). Although a long time has passed since Broca's words, scientific evidence doesn't seem to be enough to contradict the pattern of discriminatory thought based on biological citizenship by differentiating morally between members of different human groups. For instance, according to an international survey, almost 20% of the British teachers answer positively to the question "is it for biological reasons that women more often than men take care of housekeeping?" (Clément and Caravita, 2014).

In conclusion, the *science education for democracy trough conflict and dissent* framework places a strong socio-political element on learning and aims at producing knowledge in order to address socioscientific issues related to injustice. Scientific knowledge interacts with its applications in society and with the beliefs and values of other systems of knowledge production, such as those related to ethics, aesthetics, power and religion. This framework, with its concept of biological citizenship, is an interpretative lens for all those citizenship projects framed in biological terms, in terms of gender, of race, of blood lines, and so forth.

In the following chapter, I describe how Darwin's theory, with its critique of typological thinking in taxonomy (Mayr, 1975), might challenge traditional conceptions of race, ethnicity and gender sometimes at the basis of discriminatory social practices and of many biological citizenship projects. However, in the same chapter, I illustrate also that the issues of human variation and human evolution involves emotion and prejudices along with widely documented misunderstandings and misconceptions (Gregory, 2009) that can challenge biology teachers in their attempt to promote a sense of belonging to humanity as a whole.

2.4 Pedagogical and philosophical issues related to teaching Evolutionary Biology and Human Classification

Biology, evolutionary biology and, in particular, concepts of Darwinism have a role in the construction and deconstruction of biological citizenship. Darwinism is, in fact, generally invoked both by the partisans of biological determinism and by those who believe that biological citizenship is a social construction. In this section, I first outline the origin and the meaning of the different and, sometimes, contradictory ways of understanding Darwinism. Secondly, I define the term misconception and I list the common misconceptions concerning evolutionary biology that students and, in general, people all over the world seem to have. These include misconceptions related to the issue of the human classification. Finally, I conclude the chapter by contrasting Population and tree thinking with typological thinking.

Charles Darwin (1809-1882) changed our understanding of life on Earth and provided humanity with a comprehensive model with which to understand nature, revolutionising both biology and philosophy. Indeed, Darwin "gave a decisive contribution to a general gradual process, which culminated in the naturalisation of man [sic] and the substitution of a secular, naturalistic world view for the old natural theology of perfect adaptation and divine contrivance" (La Vergata, 1985: p. 952). Darwin provided humanity with a new image of nature, in contraposition to the nineteenth century established vision of a harmonious world, divinely ordained to serve God's noblest creation, mankind. 'No other work advertised to the world the emancipation of science from philosophy as did Darwin's Origin [...]. Darwin's conceptual framework is, indeed, a new philosophical system.' (Mayr, 1964, cited in La Vergata, 1985: 928)

However, the images that students and non-biologists have of Darwin and Darwinism are various and contradictory. In Darwin's day, Darwinism denoted merely the belief in evolution and the belief that humankind originated from some apes living in past geological times. At the end of the nineteenth century, the term acquired a depreciative connotation, indicating atheism, which was a philosophical position that might not match perfectly with Darwin's own thinking (Desmond & Moore, 1991). For modern biologists, Darwinism indicates the theory of evolution by natural selection and the rejection of any belief in an inheritance of acquired characters (Mayr, 1985). The terms Neo-Darwinism or New Synthesis are more appropriate terms for identifying the modern theory resulting from the synthesis between the theory of natural selection and genetics, population genetics and palaeontology. Non-biologists sometimes identify Darwinism with Social Darwinism, an ideology more related to Spencer than to Darwin (Mayr, 1975).

In the attempt to understand the multiplicity of meanings carried by the word Darwinism, Mayr's essay *Darwin's Five Theories of Evolution* (1985) provides tremendously useful insights. The thesis at the core of Mayr's essay is that Darwinian theory, in spite of being a unitary entity, is, rather, a whole bundle of theories that can be summarised as follows: (1) evolution as such; (2) common descent; (3) gradualism; (4) multiplication of species and (5) natural selection. Mayr maintains that the composite nature of Darwinian thought is shown also by the fact that immediately after 1859 most evolutionists rejected one or more component of Darwin's theory, while simultaneously accepting others.

Evolution as such is the theory that the Earth, including its living beings, is continuously transforming. The cultural obstacle to this theory is the view of a world constant and of short duration that, at the time of Charles Darwin, was taken for granted, along with widespread essentialism. In fact, essence cannot evolve. At most, essence can be substituted by the discontinuous process of production of new essences (Mayr, 1985).

The Common descent theory is the theory in which similar species descend from an ancestral species. In September 1835, when the Beagle arrived in the Galapagos Islands, Darwin still believed in centres of creation (Keynes, 2000). However, during the voyage, he collected some mockingbirds from Chile and Argentina and four mockingbird specimens from the Galapagos, one for each island he visited. What he realised then was that the differences between the birds he had seen in those islands, which are so close to each other, were greater than between any he had seen in the whole of South America.

'Analogy would lead me one step further, namely, to the belief that all animals and plants have descended from some one prototype. But analogy may be a deceitful guide. Nevertheless, all living things have much in common, in their chemical composition, their germinal vesicles, their cellular structure, and their laws of growth and reproduction. We see this even in so trifling a circumstance as that the same poison often similarly affects plants and animals; or that the poison secreted by the gall-fly produces monstrous growths on the wild rose or oak-tree. Therefore, I should infer from analogy that probably all the organic beings which have ever lived on this Earth have descended from

some one primordial form, into which life was first breathed.' (Darwin, 1859: p.520)

The concept of common descent was not completely new in the history of science: Buffon, for instance, had already used it in order to explain close relatives such as horses and asses (Mayr, 1985). Curiously, Lamarck did not consider a common descend for species, because he visualised evolution not as a branching tree but rather as a series of parallel phyletic lines, each of which is separately leading to higher perfection (Mayr, 1985). By contrast, Darwin had the idea of common descent quite early in his career, as clearly emerges from his famous sketches of branching trees in his notebooks (Darwin, 1837-38: p. 26).

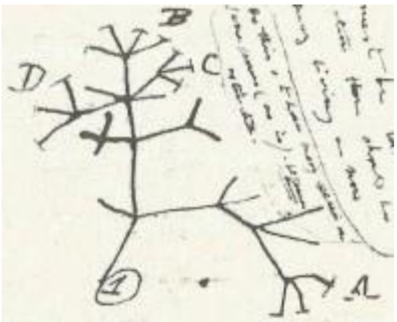

Figure 2.1 Darwin's sketch

Common descent was the component of Darwin's theory more enthusiastically accepted by scientists, possibly for its explanatory power. In fact, the common descent theory suddenly gave meaning to the comparative anatomist studies of the day, the Owen's archetypes, and even to the Linnaean hierarchical classification system. It became evident that taxa were constituted by the descendants of a common ancestor and that the more ancient the ancestor, the higher the position of the taxon.

The theory of Gradualism consists in the principle of natural philosophy summarised with *Natura non facit saltum* (nature does not proceed by jumps). This theory soon encountered strong opposition for being in antithesis with the dominant Essentialism which, at the time, was also underpinning taxonomy, the classification of living beings. In taxonomy, the essentialist position was maintained by typology which assumes that each species has an essence and that the task of taxonomy is to discern such essences of species (Hull, 1965). Darwin's theory of gradualism makes it impossible to indicate where a species ends and another begins and as a consequence challenges the ontological assertion that species' essence really exists. Darwin's idea was that new species originated from previous ones by means of a slow transformation in which each stage maintained their adaptation (Mayr, 1985).

The gradualist interpretation is inconsistent with Essentialism. In fact, if two species are merely two different phases of a single process, it may even be difficult to maintain that they are actually two different species. Living beings are the little branches of an evolving tree-of-life. The essence, if an essence must be found, cannot be found in the single species, in the little branches, but in the whole tree-of-life (Mayr, 1985).

The theory of multiplication of species, that is speciation, is the part of Darwin's theory that explains the enormous diversity of life. This theory also found great resistance because it concerns one of the cornerstones of Natural Theology. Abundance, multiplicity and variance are, in fact, with symmetry, order, connection, utility, beauty and adaptability, ingredients fundamental to looking at nature as the creation of a good and wise God (La Vergata, 1990).

Finally, the theory of descent with modification by natural selection is the most daring and the most original of Darwinian theories (Mayr, 1985). In fact, it provides a mechanical explanation, in place of the supernatural account of Natural Theology. In addition, the mechanism invoked by this theory (Darwin and Wallace, 1858) to explain how and why evolution occurs was unique: as a matter of fact, there is nothing like it in the whole philosophical literature from pre-Socratics to Kant (Mayr, 1985). Modern biologists refer to natural selection as differential reproduction because the slogan 'survival of the fittest', used sometimes to summarise the theory, is misleading as it depends on the reproductive success of individuals (Mayr, 1985).

At the present time, consensus among biologists is unanimous in considering evolution a historical fact. Even if one rejects Darwin's theory, it would be difficult to deny the reality of evolution when looking at the pattern of fossil record in rocks. However, such a consensus has not spread outside the community of Natural Sciences scholars. In fact, biologists and science teachers still face age-old resistance, misunderstanding, misconception and controversies around the theory of evolution (Bishop and Anderson, 1990; Gould, 1996; Alters and Nelson, 2002; Tidon and Lewontin, 2004; Nehm and Reilly, 2007; Gregory, 2009; Smith, 2010a; Smith, 2010b).

Although the basic explanation of the evolutionary theory I have just drawn is far from being complete, it shows that Darwin's theory is fairly straightforward and accessible to anyone. Therefore, it is legitimate to ask why the public is reported to be lacking 'even a rudimentary understanding of evolution' (Alters and Nelson, 2002: p.1892) and the reason for which misconceptions about the theory are 'extremely robust, even after years of education in biology' (Ferrari and Chi, 1998: p.1233). Interestingly, Ferrari and Chi (1998) report that faulty explanations are extremely resistant to being corrected from instructions, especially when they are due to misconception (e.g. the idea that a dominant allele tends to be more frequent in the population) rather than false beliefs (e.g. dolphins and squids are fishes).

It has been argued that students understand evolution in a previous conceptual framework which includes prior scientific and pseudoscientific conceptions, scientific and religious orientation (Demates, Good and Peebles, 1995) and incorrect versions of evolution that they learned from media, movies, family and friends (Gregory, 2009). In the assimilation and rejection of evolutionism in the Hindu context, for instance, one must also consider the possible relevance of the fact that the Hindu tradition met Darwinism in the late nineteenth century as part of the alien culture of the colonialist (Brown, 2010).

The state of public understanding of evolution is considered very poor by most researchers and educators, and educational literature documents a wide range of misconceptions in EB (Alters and Nelson, 2002). By misconceptions in EB, I mean conceptions that most scholars, scientists and biology teachers consider alternative and in contradiction with neo-Darwinian theories. These misconceptions include Lamarckian explanations; use and disuse explanations; teleological conceptions; progressive conceptions; gradual change over time conceptions; survival of the fittest explanations; Scala Naturae representations; kinship and taxonomic misconceptions; pseudoscientific and non-scientific beliefs; and from-experience and vernacular misconceptions.

Lamarckian explanations consist in explaining evolutionary changes as the response to changes in the environment for the need to survive: such an explanation implies that acquired traits can be inherited (Bishop and Anderson, 1990). Nehm and Schonfeld (2008), for instance, report students believing that mutations are adaptive responses to specific environmental agents. Even teachers (Tidon and Lewontin, 2004) and students with very strong biological backgrounds (Brumby, 1984) are reported to have Lamarckian views of evolution. Based on these views, students think that the environment itself causes change in individual characteristics, missing the key point that the environment affects only the survival of characteristics after their appearance, which is a consequence of random changes in genetic material in the population (Alters and Nelson, 2002).

Use and disuse is another Lamarckian mechanism by which students believe the environment exerts its influence on traits of the organism (Bishop and Anderson, 1990). In short, either the use or failure to use an organ has consequences on the development of that organ in a given species. Nehm and Schonfeld (2008) describe students believing that when an organ is no longer beneficial, the offspring will not inherit it. In the same line of argument, Bishop and Anderson (1990) describe students believing that the non-use of eyes for many generations results in non-functional eyes in cave salamanders.

Teleological conceptions consist in the view that biological features appear as they are for a reason. As a consequence, evolution is understood as a conscious process based on the needs of living beings (Woods and Scharmann, 2001). From this perspective, for instance, tigers' stripes are made for survival, for predatory purposes, rather than due to selection (Ferrari and Chi, 1998). Nehm and Reilly (2007) report biology students attributing 'super' hearing or smell to blind salamanders, believing, substantially, that when a faculty is lost, a heritable compensation of one trait occurs.

Progressive conception consists in the attitude that sees in evolution a purposeful striving from bacteria to humans (Alters and Nelson, 2002). In other words, students seem to focus only to the branch of the tree of life that leads to humanity, ignoring the billions of other branches that resulted sometimes in living beings less complex than their ancestral forms. In this way, evolution is understood as a triumphal history with the end goal of humans.

Gradual change over time conceptions, revealed even in students enrolled in biology courses, consists in the belief that traits change gradually in all members of a population (Bishop and Anderson, 1990; Jensen and Finley, 1995). In other words, students miss the key point that changes in traits occur when the proportion of individuals carrying traits that are favoured by natural selection grow with each succeeding generation (Alters and Nelson, 2002).

A very common misconception is that of survival of the fittest (Nehm and Reilly, 2007). Survival of the fittest is a poor descriptor of natural selection (Gregory, 2009). In fact, firstly it leads to the distorted view that only the strong survive. Secondly, it does not take into account that traits that increase survival without reproductive output have fitness equal to zero (e.g. when for example the strong survives but is infertile). Thirdly, it places the emphasis on organisms, rather than on genes (Curtis and Barnes, 1994; Gregory, 2009).

Scala Naturae concepts are the idea that living beings are ordered along a linear scale where humans have the highest position. The idea of Scala Naturae is difficult to tackle because despite being clearly in contrast with the strong stochastic component of evolutionary processes, it has been, for centuries, a powerful metaphor in Western cultures (Tidon and Lewontin, 2004).

Kinship misconceptions consist in the perception of contemporary living beings as primitive forms. For example, rather than ‘cousins’, contemporary monkeys are considered humans’ ancestors (Alters and Nelson, 2002).

Taxonomy misconceptions are reported to be reinforced by Biology textbooks. In fact, in most evolutionary trees, taxa (e.g. groups of living beings – such as species, mammals, vertebrates) are ordered in an anthropocentric manner, by placing, for example, the taxon containing our own species in the rightmost position (Sandvik, 2008). For example, the cladogram shown below, which depicts the phylogeny of bony vertebrates, is anthropocentric because both the resolution of its branches and the ordering of taxon names are biased in favour of mammals.

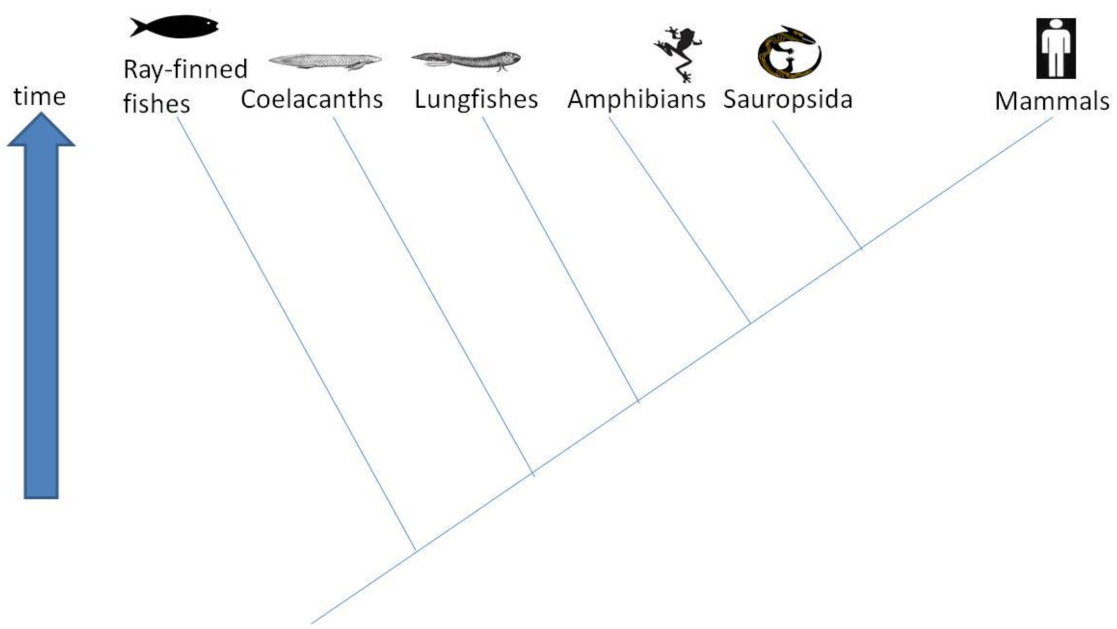

Figure 2.2 Cladogram depicting the phylogeny of bony vertebrates

Sandvik's research shows that not a single student, in his research, was able to give the correct answer to the question "Which species is/are most closely related to species B?" in the following cladogram (i.e. C, D, E and F).

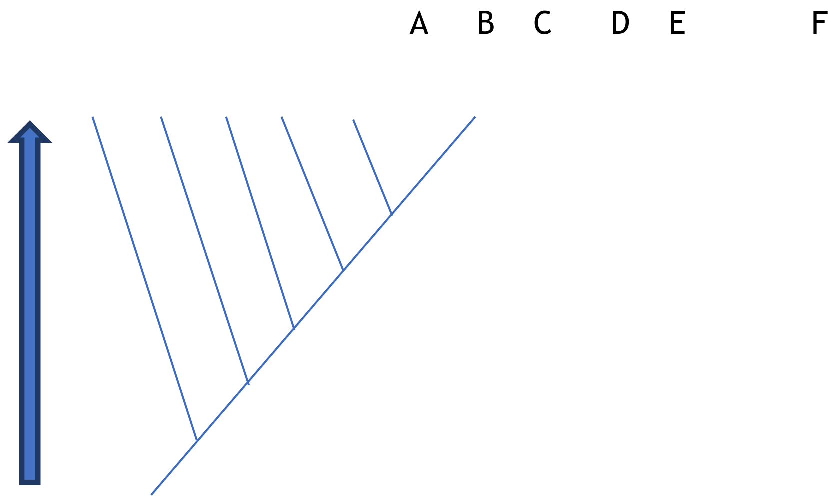

Figure 2.3 Example phylogeny, where letters symbolise species

Pseudoscientific and non-scientific beliefs sometimes impede the understanding of evolutionary biology. For instance, it is a common practice in evolutionary psychology to describe human subsets by mixing physical, behavioural, social and cultural characteristics and to consider them in some way the products of natural selection that has occurred in humanity's ancient past. Nehm and Reilly (2007) report biology students believing that drastic climate changes are necessary for evolution to occur. Pullum (1993), in a communication analysis of Time, Newsweek, and U.S. News and World Report, illustrates that, these periodicals although accurately portraying evolution, typically mention the possibility of supernatural causality in the same articles. Such juxtaposition of science and supernatural causation in articles about biological evolution may lead to confusion among casual readers.

From-experience misconceptions are those that students surmise from their everyday experiences. For instance, the idea that humanity is an outcome of a series of mutations clashes with the students' from-experience misconception that mutations are always detrimental to fitness (Alters and Nelson, 2002).

Vernacular misconceptions consist in confusing terminology by applying the everyday meaning of words instead of the scientific meaning. As a consequence, new knowledge is constructed with this faulty understanding (Alters and Nelson, 2002). The words adaptation, fitness, dominant, fit/dominant and theory are cases in point.

Adaptation is often used to mean acclimatisation, meaning all the individual changes to physical or behavioural features in response to an environmental condition (Alters and Nelson, 2002). As a consequence, for instance, the individual acclimatisation to cold or hot weather conditions may depend on biological factors (lipids), behavioural factors (training) and psychological factors (homeland). In life sciences, the word adaptation has a very different meaning. Adaptation does not refer to changes in individual features over a lifetime in order to get used to an environmental condition. It is a process that occurs over hundreds of thousands, if not millions, of years. Adaptation is the outcome of natural selection on the population variability of the genetically determined features. Bishop and Anderson (1990) report students not giving any role to variation in traits within a population or differences in reproductive success. In addition, this results in reinforcing another misconception, which is the Lamarckian idea that the environment forces individuals to change. In fact, the same students are also reported to attribute change in traits to a need-driven adaptive process rather than to random genetic processes.

In evolutionary biology, individual fitness is a measure of the relative number of the alleles (i.e. variety of genes) in the next generation (Curtis and Barnes, 1994). To put it simply, it is a measure of reproductive advantage. Any genetic characteristic that increases the ability of individuals to produce surviving offspring is said to increase their fitness. However, fitness is sometimes understood as an individual being fit, strong or intelligent (Tidon and Lewontin, 2004).

'Dominant' refers to the allele that has the same effect in both the heterozygote and homozygote states. However, by giving a vernacular meaning to the word dominant, students tend to believe that the dominant alleles tend to prevail over the recessive varieties (Alters and Nelson, 2002), missing the Hardy–Weinberg principle that is that the frequencies of alleles remain constant in the absence of selection, mutation, migration and genetic drift (Campbell et al., 2008). In addition, Nehm and Reilly (2007) report biology students giving to 'fit' the meaning of dominant, and to 'unfit' the meaning of recessive, in the allelic sense.

'Theory' is often given the meaning of hypothesis. On this basis, on believing that evolution is merely a hypothesis without scientific foundation, it becomes legitimate to doubt it (Alters and Nelson, 2002). Bishop and Anderson (1990) report that teachers' instructions are producing only a slight change in students' beliefs about evolution. Stephen Gould reports a text in a biology textbook: 'The theory of evolution is the most widely accepted scientific explanation of the origin of life and changes in living things. You may wish to investigate other theories'. Gould points out that similar suggestions are not issued for any other well-established theory. Students are not told that 'most folks accept gravitation, but you might want to check out levitation' (Gould, 1991, cited in Barbera et al., 1999: 107).

By using the words theory and hypothesis interchangeably, the Evolution-Creation debate is often merely reduced to a dispute between two different kinds of faith (Bishop and Anderson, 1990). In this way, even the official acceptance of evolution by many religions and religious thinkers is undermined. For instance, the Catholic Church, since 1996, officially accepts evolution:

Today, more than a half-century after the appearance of that encyclical, some new findings lead us toward the recognition of evolution as more than a hypothesis. In fact it is remarkable that this theory has had progressively greater influence on the spirit of researchers, following a series of discoveries in different scholarly disciplines. The convergence in the results of these independent studies—which was neither planned nor sought—constitutes in itself a significant argument in favour of the theory (Pope John Paul II, 1996).

However, strong resistance to teaching evolution is made by very diverse creationist organisations (Lerner, 2000). This phenomenon, despite being more relevant in the United States, is also emerging in other countries (Tidon and Lewontin, 2004; Allgaier and Holliman, 2006). Young-earth creationists, for instance, who range from factions of evangelical Protestants to ultra-orthodox Jews and Muslims, object to the truthfulness of evolution as they believe the Earth to be much younger than the scientific evidence implies. Others, such as some Native American religions, believe that Earth and humanity have been as they are for an infinite time (Lerner, 2000). A further objection to evolutionism is maintained by creationists embracing the intelligent-design position who hold the belief that life is too complex to simply have evolved and thus must have been created by an intelligent designer (Grimm, 2009).

Hence, difficulties in teaching and learning evolution result, substantially, from the fact that, all over the world, students are reported to understand evolutionary theory in a Lamarckian way, cultivating the ideas that the environment forces individuals to change, that in nature only the strong survive and that evolution is merely a hypothesis. Difficulties stem also from the fact that human evolution might provoke anxiety about the status of humanity in the natural world (Lerner, 2000). In addition, students have previous explanations of natural phenomena. These explanations, despite being naïve, seem to be widely accepted in several parts of the world probably because they are easy to understand and apparently logical (Tidon and Lewontin, 2004). In fact, a natural world where organisms designed to survive in their environment are able to acquire traits that are necessary to survive environmental changes seems quite logical, although nature, according to EB theories, does not operate in this manner (Bishop and Anderson, 1990).

A further complication arises from the strong emphasis on micro processes in evolutionary biology education and the virtual lack of understanding of the history of life on our planet, by both students and teachers (Catley, 2006). This might be related to the difficulty in accepting the revolutionary contribution of Darwin’s theory to taxonomy and, in particular, to human classification, consisting in replacing typological thinking by population thinking (Mayr, 1975). This is also the last topic investigated by this literature review.

Contemporary evolutionary biology challenges the traditional view that attributes to humanity properties that cannot be found in other animals. In fact, molecular biology, cytology, anatomy, physiology and genetics studies show that, for instance, humans, chimpanzees and gorillas are clearly very similar models of the same kind of animal. Those apes present extensive similarities with us also at the behavioural, psychological and social level. They can learn to understand a few thousand human spoken words; they can communicate with us in sign language in quite a complex way; they have deep emotional reactions to emotions commonly associated with humans, such as pain, suffering and happiness; they understand the concept of death; they show love and friendship; they suffer for the death of those they love; in their wild societies they are divided in groups of allied individuals, and make wars; they seem to understand forms of human art; and they show emotions when looking at books and movies.

In other words, great apes clearly show features that for centuries were associated exclusively with our species. The extension of features commonly associated with humans to other animals diverges from typological thinking. This concept, related to the philosophical movement of Essentialism, dominated pre-Darwinian taxonomy for centuries and is in contrast with population thinking that underpins Neo-Darwinian taxonomy. Mayr (1975) maintains that virtually any controversy in evolutionary biology is ascribable to a controversy between typology and population ways of thinking.

Although biologists do not acknowledge any validity of typological thinking in classifying living beings, typological thinking still has popular acceptance. Being related to the philosophical positions of Essentialism, typological thinking sees each species and each race as characterized by a peculiar essence, namely, a set of features distinct from all other species or races. Individuals with different features are believed to be deviating from what is considered typical (i.e. the essence). Therefore, for instance, eighteenth century natural theology considered the human appearance of north-European Caucasoid people conforming to the human essence. People with different appearance were considered with a certain degree of abnormality (Gould, 1996). In opposition, from a Darwinian point of view, typical features are nothing more than statistical abstractions of a population of animals or plants.

There is clear evidence that lay theories about living beings incorporate essentialist biases (Gelman and Rhodes, 2012). However, essentialism represents a constraint in understanding biology and, in particular, biological taxonomy because it leads to category mistakes. For instance, Gelman and Rhodes (2012) attribute to essentialist biases a set of intuitive beliefs that result in understanding certain categories as real, rather than as human constructions. Therefore, these categories are believed to be natural, discovered, information-rich and bearing an underlying causal force, the essence, that is the ultimate reason for category members being the way they are (Gelman and Rhodes, 2012).

Such a supposed essence is believed to be real, although people typically do not have knowledge of what the essence is. Sometimes essence is interpreted approximately as genes or DNA, although not with any scientific notion of genes and DNA (Gelman and Rhodes, 2012). Category members are believed to share deep similarities, including invisible shared properties, even in the face of superficial diversity. Research investigating the beliefs of children illustrates that essentialism is a fundamental component of human cognition and of our intuitive ways of understanding the biological world (Coley and Muratore, 2012; Shtulman and Calabi, 2012).

All racist theories are built on the typologist assumption that any individual of a race differs from any individual of any other race by the typical features which represent the type (i.e. the essence) of a given race (Mayr, 1975). Substantially, typologists believe that any individual conforms to the type of a given race and thus is separated from the individuals of other races by a distinct gap. In the Darwinian population thinking, on the contrary, any individual is characterised by thousands of features each of which varies to a certain degree from the mean of the population, independently of the others. Individuals who are characterised by the average value for every feature simply do not exist. Hence, the ideal type of any race is only an abstraction (Mayr, 1975).

Another key contribution to taxonomy given by population thinking, and implicit in Darwinian theory, is the rejection of the typological way of considering living beings in terms of good/bad and useful/detrimental. From a typological point of view, evolution, when accepted, is a progression because natural selection is meant as the mechanism by which the superior types of each generation are preserved and the inferior ones are rejected. From a Darwinian point of view the target of natural selection is the individual. Each individual bears thousands of traits, each of which varies around the population mean. Of course, the higher the number of traits with values that increase the probability of surviving, the higher the probability of reproduction. However, it is a matter of probability and 'under certain environmental conditions and temporary circumstances, even a ''superior'' individual may fail to survive or reproduce' (Mayr, 1975: p. 328).

In addition, in population thinking, the stress is on the 'uniqueness of everything in the organic world' (Mayr, 1984: 158). Every human is unique as well as every individual animal or plant, and even individuals change throughout their lifetime: as a consequence populations are made of unique organic entities and species can be described only in statistical terms (Mayr, 1975). However, any statistics are abstraction; only the individual organic entities are reality.

The ultimate conclusions of the population thinker and of the typologist are precisely the opposite. For the typologist, the type (eidos) is real and the variation an illusion, while for the populationist the type (average) is an abstraction and only the variation is real. No two ways of looking at nature could be more different (Mayr, 1975: 158).

Therefore, if an essence must be found, it cannot be found in the species or in the race, but in each individual. Darwinian population thinking stresses the uniqueness of every individual of any species and thus its assumptions are diametrically opposed to those of the typologists (Mayr, 1975). Not only are there no two individuals that are identical, but each individual changes continuously during its life. After Darwin, task of human classification is not to discern the essence of humanity. Rather, it is to classify the degree of kinship that any human being has with all the other humans of the world and with all the other living beings of this planet. Phylogeny is in this way conceived as a tree of life that substantially means shared ancestry. Therefore, at its base, evolution is about the common ancestry of living beings (Scott, 2012) and the study of life is substantially the theory of phylogenetic trees (Baum and Offner, 2008).

Taken together, the findings of this section of my literature review highlight that there are conceptual problems in people's understanding of macroevolution, that is the processes that occur at the level of species and above. These problems seem to be even more difficult to tackle for the educators because of the abovementioned essentialist intuitive ways of classifying living beings. In fact, many who believe in creationism sometimes accept evidence for microevolution, such as the evolution of pesticide resistance in insects and antibiotic resistance in bacteria, but remain against macroevolution (Evans et al., 2010). Macroevolution is difficult to accept for non-biologists also because it cannot be observed, as it occurs over a period of time that is much longer than the human life-span. Therefore, educators should provide a testable framework within which evidence-based evaluation of the history of life can occur. "Tree thinking, a tool from evolutionary biology, provides such a framework" (Catley et al., 2012: p.93).

Advances in genomics data collection and computation have hugely improved the capacity to generate phylogenies, helping tree thinking to expand its influence well beyond evolutionary biology and into fields of study that range from epidemiology to forensic and gene identification (Yates, Salazar-Bravo and Dragoo, 2004). Therefore, tree thinking and phylogenetic literacy should be part of the scientific literacy of students, as citizens are frequently asked to make decisions concerning a variety of contemporary issues that rely on phylogenetic analysis.

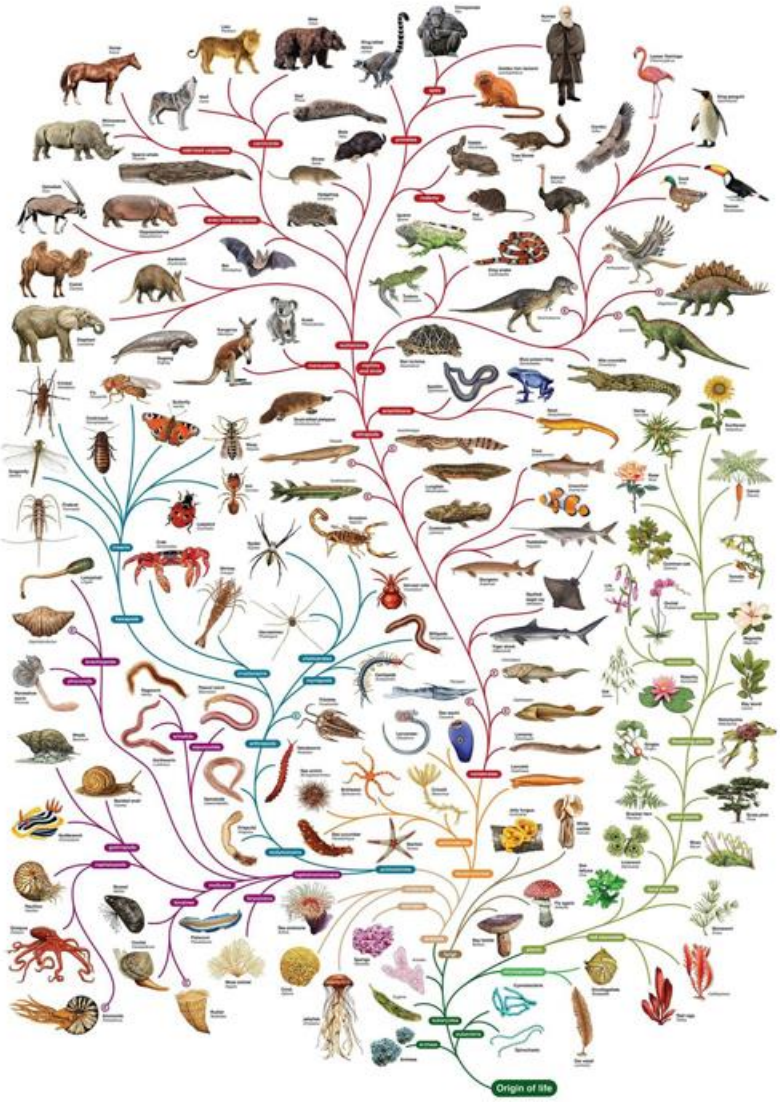

Figure 2.4 The Open University Tree of Life, online:
http://www.open.edu/openlearn/nature-environment/natural-history/tree-life

2.5 Conclusions and possible research gaps

“There is a grandeur in this view of life”, wrote Darwin referring to evolution (1859: p.490). However, the state of public understanding of evolution is considered woefully lacking by most researchers and educators and affects science literacy and educational research (Alters and Nelson, 2002). In addition, researchers, curriculum developers and sometimes,even biology teachers do not seem to grasp such a grandeur, in their role of educators of young citizens. Scott (2012) argues that a nation in which citizens fails to understand the organising principle of biology will be at a disadvantage. “If our students are not learning to understand evolution, they will be poor candidates for the jobs of a future economy increasingly dominated by biological concerns in biotechnology, genomics, agriculture, medicine and ecology" (Scott, 2012: p.xii).

This literature review illustrates that the potential inherent to delivering science lessons as a means for contributing for citizenship education has a long history. In school biology, the application of science in society, biotechnologies and related bioethical issues plays the main role in citizenship education. However, although teachers generally tend to embrace the idea of teaching socioscientific issues, far fewer actually incorporate the SSI into their teaching on a consistent basis (Sadler et al., 2006). In addition, evolution, the key and universal explanatory framework for understanding life on this planet, not only seems to encounter resistance due mainly to the problem of students' prior conceptions, but also seems not to be included in the scientific literacy standards required of citizens of our global society. In fact, although "evolution is one of science's most robust and well tested theories" (Sadler et al., 2006), in some cases it is completely avoided because it is perceived as having the potential to challenge students' and parents' beliefs (Sinclair and Baldwin, 1995; Trani, 2004; Sadler et al., 2006).

Biologists agree that evolution is the bedrock of the life sciences (Scott, 2012). The evolutionary processes are universally recognised to be the ultimate cause of biodiversity. In addition, the completion of the Human Genome Project provides humanity with significant and conclusive knowledge about human biodiversity. Citizenship identities are sometimes related to exterior biological features due to environmental adaptation. Many citizenship projects are based on the supposed biological features of its citizens. However, the link between science literacy, evolution education and citizenship education does not seem to be an explicit object of careful examination from educational research.

As a matter of fact, several educational issues do not seem to be objects of inquiry in educational research. These are: how evolutionary biology and advances in genetics and molecular biology inform school science about all those citizenship projects that can be clustered with the term biological citizenship; how teachers can guide students so that scientific misconceptions about citizens diversity do not arise; how biology teachers, in their attempt to wrestle with the problems that students encounter in learning difficult evolutionary concepts, link citizenship education to tree thinking and population thinking, are all educational issues that do not seem to be objects of inquiry in educational research.

After investigating the overarching research question of my study, within the educational literature, I cannot say that an explicit link between school evolutionary biology and global citizenship education is clearly emerging. I found a number of potential opportunities for school evolutionary biology to contribute to citizenship education. For instance the scientific rejection of race; the critique to biological determinisms; the population thinking and the arguments against essentialism in classification and, in particular, in human classification; the common origin theory and the tree thinking; the magnitudes of the biological differences among humans and between humans and other species; the findings of the Human Genome Project and hundreds of similar projects; the issue of animal rights; the call for inclusion of phylogenetic thinking in the scientific literacy of citizens; and the debates on socioscientific issues related not only to biotechnologies but also to the attempt at biologising cultural human differences. I also found constraints. For example, the teaching of evolution simply as a topic of biology; the strong emphasis on microprocesses in evolution education; the virtual lack of understanding of the history of life on our planet, by both students and teachers; the lack of understanding of evolution in evaluating issues of bioethics, human origins and cloning, among others; antievolutionist cultural environments; extremely robust misconceptions about evolution; and category mistakes.

However, although there is extensive research on citizenship education through school biology connecting, for example, society with issues of ecology, or food security and bioethics, there does not seem to exist in the literature a homogenous body of research investigating in a systematic and explicit way the interplay between evolutionary biology and citizenship education in secondary schools. In addition, research exploring what teachers think about teaching evolutionary biology with the aim to educate for global citizenship is clearly under-represented. I agree with Sadler et al. (2006) when they maintain that “efforts to develop and promote curricula which highlight SSI as well as ethics and values associated with science, must account for teachers’ perspectives on these issues”.

For this reason, I thought that an empirical study of teachers’ conceptions about the interplay between global citizenship education and school evolutionary biology could make a useful contribution to both the citizenship education framework and that of teaching evolution. This exploratory study, investigating the interplay between global citizenship education and school evolutionary biology, is an attempt to provide insight into this research gap.

As human beings, we are condemned to meaning as someone has put it

(Säljö 1997: p.177)

Chapter 3: Methodology

3.1 Ontological and Epistemological positions

This research is conducted adopting a philosophical stance that rejects the simplistic notion of paradigm in educational studies that divides realists, maintaining the ontological assumption of an objective social reality, and constructivists, believing that social phenomena are always subjective and that there is no social reality independent of perception (Bryman, 2008). Such a notion of paradigm in educational research stems from a distortion of Kuhn's use of the word (Coe, 2012) and usually indicates a collection of ontological and epistemological assumptions.

Such a notion, in educational research, is problematic and not always useful (Coe, 2012). For instance, the complexity of social phenomena, their interactivity and contextual dependence make constructivist methodological approaches essential tools for investigating the nature of cultural constructions of social phenomena. However, this does not mean that an objective reality, that is a reality independent of the researcher, does not exist.

I substantially agree with Pring (2000) when he maintains that our conceptions and our perceptions of reality are far from being an individual construction of the world. On the contrary, we inherit them, we acquire them from the social world in which we live. However, although socially developed, our conceptions are possible because certain features of reality make them possible (Pring, 2000). Imagine we have the task of classifying the following animals: a dog with long white fur, a white cat with long fur but no tail, a black dog with no tail and a black cat. The fact that we would probably distinguish between dogs and cats depends upon a reality that exists independent of us (i.e. the reproductive barriers between the two species). Hence, the two species are true and objective realities independent of our existence. We might have distinguished these animals on the basis of their colour, fur or tail as well. The alternative classifications would have been equally based upon reality independent of us.

Believing in an external reality independent of human knowledge, a reality subject to multiple interpretations, one that is difficult to understand and sometimes impossible to measure, my ontological stance can be related to critical realism (Snape and Spencer, 2003). My stance is critical because I recognise the need to identify and change the structures at work that generate socio-cultural events (Sayer, 2000). I agree neither with the view that the external world is as it is perceived, nor with the relativist idea of the incommensurability of different perspectives, the idea that we can never understand each other because we come from different experiences and cultures.

My stance is also influenced by structuralist beliefs, in the view that one's ideas and actions are not really determined by personal choice, but by underlying structures in society reducing human subjectivity and human agency (Craib, 1992). The same idea is also present in Durkheim's sociological theory: 'there are ways of acting, thinking and feeling which possess the remarkable property of existing outside the consciousness of the individual. Not only are these types of behaviour and thinking external to the individual, but they are endued with a compelling and coercive power by virtue of which, whether he [sic] wishes it or not, they impose themselves upon him' (Durkeim, 1982: p. 51). However, as I also accept the concept of learning as the process of changing a previous system of knowledge, behaviour and values, I do not think that the underlying structures necessarily result in what sometimes has been summarised with the structuralist slogan 'the death of the subject' (Craib, 1992: p. 135). My commitment to structuralism substantially consists in my interest in revealing the structures underlying individuals' meanings.

In social science, structuralism consists of the (social) scientific attempt to understand those underlying structures by analysing basic elements such as words, concepts and actions and the rules by which they are combined (Dreyfus and Rabinow, 1983). For instance, in order to identify the structure of language, structuralists start from the observation that all language elements are arbitrary signs, established purely by convention (Harrington, 2005). Eco maintains that signs are "everything that, on the grounds of a previously established social convention, can be taken as something standing for something else" (Eco, cited in Seiter, 1992: p.5).

The founder of modern linguistics, Ferdinand de Saussure, maintains that signs are a combination of *signifier*, the emitted sound, icon or the written word, and *signified*, the concept to which the signifier conventionally refers (Benton and Craib, 2001). For example, the concept of water (signified) has different signifiers (words) in different languages. The relationship between the signifier and the signified is conventional and completely arbitrary. However, such an arbitrary feature of language does not imply that we can choose any signifier as we like: the language we speak exists before we are born and, in order to communicate with others, we have to follow the conventional rules of our linguistic community. The structure underlying a language consists of signs and the rules by which these signs are combined (Harrington, 2005).

Saussure argues that the structure underlying the language uses binary schemas in which difference creates meaning (Harrington, 2005). In defining the word ‘left’, for example, one defines the word ‘right’ at the same time. In addition, in the linear sequence of letters in a word and of words in a sentence, these elements gain value through their linear relationship with the other elements present in the linear chain. However, language is not only a means of expression. Rather, language is the structuring precondition of individual thoughts and thus individuals, to a certain extent, are not the subjects of their language, but the bearers. As a result, individuals gain access to their identities only through the institutionalised totality of language (Harrington, 2005).

From these assumptions, it has been argued that any culture, being to some extent a means of communication, can be studied making an approximate analogy with language (Craib, 1992). Claude Lévi-Strauss, for example, applies the methods of structural linguistics in an attempt to uncover the universal structures underpinning the apparent diversity of human societies (Harrington, 2005). The ultimate structure for Lévi-Strauss is the structure of the mind (Ritzer, 1983): 'The unconscious activity of the mind consists in imposing forms upon content, and […] these forms are fundamentally the same for all minds – ancient or modern, primitive or civilized' (Lévi-Strauss, 1967, cited in Ritzer, 1983: 282). However, the mind is not accessible to direct observation and for this reason he argues that the analogy with structural linguistics allows study of the unconscious structure of linguistic phenomena.

According to Lévi-Strauss, racism, for example, is a universal phenomenon common to any human societies based on various dichotomies (e.g. Greco-Roman versus Barbarous; civilised versus savage) all ascribable to the binary scheme of culture/nature. 'In both cases, there is a refusal even to admit the fact of cultural diversity; instead, anything which does not conform to the standard of the society in which the individual lives is denied the name of culture and relegated to the realm of nature' (Lévi-Strauss, 1952: p. 11).

Therefore, structuralism is useful as a methodological approach as "it can tell us things about the world that we could not find without it" (Craib, 1992, 133). It can act as a guide for understanding general meanings, as it assumes that, within a cultural context, the meaning of an element of the language is not independent from the others. Rather, each element derives its meaning from its relationship to every other element in the system and it is produced by its difference from the others (Seiter, 1992). This is relevant in the social sciences and in the analysis of texts that will consist in revealing how words indicate interpretation and how lexicon and syntax induce response (Eco, 1979).

3.2 The conceptual framework of this research

The conceptual framework of this research draws on concepts from various theories and findings in the research field of secondary school science education and consists in a type of conceptual map framed within the following research and theoretical cornerstones:

- Evolution and tree thinking as essential components of the scientific literacy of citizens
- SSI movement
- *Biological Citizenship* and cosmopolitan education

The first cornerstone of this research is well described by the auspices of the National Academy of Sciences: “the theory of evolution has become the central unifying concept of biology and is a critical component of many related scientific disciplines. […] The teaching of evolution should be an integral part of science instruction” (1999, cited in Asghar et al., 2007: p. 1-2). Therefore, a first educational concept delimiting the field of this research is the idea, generally recognised among biologists, that evolution is not a topic of biology, but the key framework for the universal interpretation of life (Dobzhansky, 1973; Korey, 1984; Scott, 2012). Related with this, a finding from educational research that underpins the project of my study is the fact that the teaching of macroevolution and phylogenetics seems to be underrepresented in American schools (Catley et al., 2012). In this regard, Catley argues that “increasingly, issues of bioethics, human origins, cloning, conservation, bioengineered food stuffs, etc. are being cast in a light that requires an understanding of macroevolutionary events and the history of life on the planet. To deny our students access to this debate is to deny the call for universal science literacy” (2006: p.775).

The second cornerstones delimiting my research stem from well-documented difficulties in teaching and learning EB, in particular the misconceptions in biology taxonomy that seem to be related to the intuitive essentialism we use for interpreting living beings (Coley and Muratore, 2012). In addition, the recent calls to introduce tree thinking into the science classroom (Goldsmith, 2003; Baum et al., 2005; Catley, 2006; Catley et al., 2012) in order to provide students with the understanding of macroevolutionary processes are also essential for interpreting issues of bioethics, human origins and cloning (Catley, 2006). In other words, part of educational research calls for linking EB with the SSI movement, the main contemporary framework educating in citizenship during the science classrooms.

Finally, this study draws on concepts of the previously mentioned Biological Citizenship (Rose, 2007) and of cosmopolitan thought. The former is a useful descriptor of how humanity is classified at times on the basis of supposed biological differences, producing a vision of a divided humanity that is not supported by advances in genomics and evolutionary biology (Gould, 1996; Pigliucci, 2013). The latter makes use of biological arguments in promoting cosmopolitan education. For instance, Appiah (1990), through the rejection of the categories of the so-called human races, stemming from the stoic idea of human dignity, proposes a form of cosmopolitan education based on Contact Theory (Appiah, 2008). Nussbaum, by raising the so-called ‘animal problem’ (Nussbaum, 2003) proposes a cosmopolitan theory that aims at promoting compassion beyond the barriers of race, gender and ethnicity and that includes non-human animals.

3.3 Research design and methods

I started these PhD studies with the proposal to investigate the opportunities and the issues in teaching EB in secondary school with the purpose to promote GCE. After the review of the literature, it is clear that:

1) the contemporary conceptions of CE in science classrooms favour students’ involvement in dialogues on controversial issues such as genetic modified food and stem cell research
2) although the theory of evolution is sound as much as the theory of gravity, persistent constrains to the teaching of EB are reported all over the world
3) these constrains include the persistence of typologist thinking in classification which presupposes the existence of an unidentified “essence” by which the members of a category (e.g. species, race, ethnicity, gender) must be compared
4) it is not clear to what extent compulsory science curricula allow for inclusion of topics of EB related to human classification and the issues of race, ethnicity and gender
5) the CfE is an ambitious school curriculum that demands the integration of school biology with the other subjects, in a holistic and inclusive citizenship education project
6) teachers’ beliefs are related to both students’ learning processes and implementation of curricula
7) there are studies on teachers’ conceptions about aspects of teaching EB, in particular those intersecting with religion. However, many aspects are totally ignored and there is no research on science teachers’ conceptions on the role of EB in CE
8) there is no research exploring to what extent science teachers consider the scientific view on race, ethnicity and gender a key element of the scientific literacy of citizens

9) there is agreement that curricula should be informed by teachers' beliefs and conceptions. However, it is unknown if the biology teachers consider the issues of human classification and animal rights eligible as SSI for CE

10) it is unknown if teachers think that the issues of biological determinisms and the common origin of humanity should be part of any science curriculum

Therefore, I planned an empirical research component that could provide data from both the curriculum and the teachers. I planned to collect official educational documents, official supporting didactic materials for biology teachers and biology textbooks, in order to gather data about the biology curriculum produced prior and independently from my empirical intervention. In addition, I planned to collect information directly form the biology teachers through semi-structured in-depth interviews, in order to access to teachers' perceptions and conceptions.

This resulted in two main data sets for analysis: educational documents relating to biology education, evolution education and global citizenship education; and transcripts from semi-structured interviews on teacher understandings of GC, GE and its relationship with topics in biology and evolution. Hence, I chose to interpret data in two phases. Firstly, through a critical review of the official educational documents. This consisted in the ideological/semantic analysis of narratives in organisational and institutional documents related to the Scottish national school curricula, biology textbooks used in Scottish public schools and official supporting materials for biology teachers. Secondly, through a phenomenographic analysis of the transcripts of the semi-structured in-depth interviews with the biology teachers.

I planned the document analysis also for other reasons. Firstly, simply to provide information about the educational settings in which the participants in the interviews were acting, as science educators, i.e. for understanding what CfE curricular context has been constructed to enable the biology teachers to promote CE. Secondly, to balance the fact that the sample of the volunteer teachers I interviewed was not representative of the whole population of the biology teachers of Scotland, so a deeper understanding of the context in which they were working was valuable. I was also seeking convergence and corroboration through different sources of data.

For the second data set, the choice of semi-structured in-depth interviews, as a further method of data collection, is justified by the fact that this method is suitable for exploring the ways in which people conceptualise social phenomena. In fact, Kvale maintains that “a qualitative research interview attempts to understand the world from the subjects’ point of view, to unfold the meaning of peoples’ experiences, to uncover their lived world prior to scientific explanation” (Kvale, 2008: p.xvii). Although my sample was intentionally not representative, I considered essential to interview the teachers because they are the professionals working within the implementation of a curricular reform and as such most informed about the opportunities and the difficulties in teaching EB in the secondary schools of Scotland and in educating for global citizenship.

Although interviews have a long history in sociology and anthropology, in educational research they have become extensively employed only in the last few decades (Kvale, 2008). In my study, the method was particularly useful because, as I mentioned and as I will justify later, I planned to analyse the data through a phenomenographic approach. Although, in theory, there are many data sources that can reflect how people understand and conceive an aspect of reality (e.g. observations, writings), many phenomenographers agree that conceptions are most accessible through language and the method of discovery in phenomenography is usually individual interview (Orgill, 2012).

Rather than open interviews, I opted for semi-structured in-depth interviews. First because this method guarantees that the interviews are deep. This means that they are supposed to finish when the interviewees have nothing else to say about the topic. This method also allows the interviews to follow unexpected ways of reasoning of the participants. However, the semi-structured feature allowed me to have a complete list of questions that I intended to discuss with all the participants in this project.

The interview protocol was designed in a way that the questions reflected the research purpose. This was not an easy task and it was quite time consuming. In the final version, the interview protocol was designed in order to focus around three series of themes related to the research questions. Each series of themes included a few open-ended questions (Appendix 1) intended to gather information about:

- the conceptions of GCE in the biology classroom
- the conceptions of the link between EB and GCE
- approaches and challenges in bringing GCE and EB issues together into the biology classroom

Although qualitative interviews are an excellent means for gathering data, I recognise that they are not unproblematic. For instance, Myers and Newman (2007) analysing the problems and the pitfalls of the method consider the interviews as an artificial situation in which two or more strangers interact under time pressure and sometimes with lack of trust for which the participants might choose not to divulgate information they consider sensible. In addition, Fontana and Frey (2000) maintain that the researcher is not neutral, is part of the interview they seek to study and he or she is influencing, if not interfering with the interaction with the participants. They also reveal an even more problematic factor affecting this method. That is the fact that participants are asked to conceptualise issues they may have never considered before. For the need to appear knowledgeable and rationale, they might be induced to construct a rational and consistent fictional story.

I am quite aware that data, especially in qualitative research, are not something that are ‘out there somewhere’ and ready to be gathered by the researcher. Rather, they are socially constructed entities emerging from the interaction between interviewer and interviewee and interpreted by the researcher. For this reason, I tried not to lead the participants’ answers. However, I recognise that by simply asking questions, I influenced the data constructed. I was aware of this during the interviews because I had a previous experience with this method, as I had used it for my MSc degree research.

The awareness of the risk of inducing in the participants answers, led me to mention in the teachers’ invitation letter to participate in the research, that the topic of the interview would revolve around the issue of GCE through SB, without specifying the part of SB I was particularly interested in (i.e. EB). This was neither a sort of covert research nor a sort of disrespect toward the participants. I planned the scheduled of the interview in a way that the teachers would initially discuss their conceptions of GCE in the biology classroom. I thought that some of them may mention the common origin theory and other EB-related topics but others may not. As I was interested in the genuine thoughts of the teachers about these issues, the second part of the interview (in which these themes were planned to be discussed) was intended to surprise the interviewees. I was not interested in their planned, politically correct, answers. As I have mentioned in the ethical considerations that follow this section, the invitation letter to the teachers were preceded by a letter to the head teachers who could read the whole interview protocol. I am aware also of the fact that some head teachers might have let the biology teachers to read the interview protocol before the interview.

I believe that the choice of these methods is in accordance with my ontological and epistemological positions. In fact, this research design includes qualitative methods framed in a critical analysis aiming at discovering the multiple, but limited, interpretations of reality by people. Qualitative approaches seem to me the most appropriate to capture the richness of the individual understanding and the situational specific of the social constructions. I agree with scholars who consider these approaches capable disclosing beliefs, values, concepts and understanding of people in their society (Waring, 2012). In addition, I think that these methods allow to reveal patterns in ideas and words: patterns in written texts of the documents and textbooks and patterns in the spoken words of the biology teachers.

Identifying patterns is a means for identifying the structures that are the underlying models of the world that exist independently of our knowledge and of our actions (Craib, 1997). We do not have access to people minds. However, we have access to language, which is the underlying structure behind communication: by looking at the relationships between the different part of language we might get access to those structures, in the same way in which, by studying the relationships between different parts of a society, we can understand that society.

All human products are, in a way, forms of language and from art to science, from music to poetry, patterns in languages are making sense of phenomena and discourses in society. When teachers talk and when curricula makers write biology specifications, their words and structured talks and texts reflect not only the temporary pragmatics of those communicational contexts. They also reflect broader patterns in collective sense-making and understanding (Wetherell and Edley, 1999). Therefore, in my role of social scientist, my purpose is to explore the patterns underpinning the social phenomenon I am investigating.

3.4 Conducting data collection and ethical considerations

The data collection consisted in two phases: in the selection of the educational documents, textbooks and other didactic material and in the collection of interviews from volunteer biology teachers.

The main issue related to the former is the reliability of the documents and textbooks. With regard to the selection of the textbooks, it was not a difficult task. In Italy, the market of the textbooks is as big as 600 million of euros each year. As secondary school science teacher, my job includes the evaluation of the new textbooks that each year the editors try to sell to schools. In addition, in Italy I use also CLIL methodology, that is Content and Language Integrated Learning, a language immersion approach that aims at teaching subjects such as science, history, geography and art through a second language which, in my classrooms, is English. As a consequence, I am constantly searching for original British and American science textbooks and original didactic materials in English. Therefore, in 2007, when I first arrived in Scotland, before starting my PhD studies, I collected a number of Scottish secondary school science textbooks. Although these textbooks were not framed within the *CfE*, I was already familiar with Scottish biology publications for secondary schools when I started my studies. Moreover, at the time of the implementation of the *CfE* my daughter was attending a state Scottish school and therefore I had easy access and I was familiar with to her didactic materials. In addition, some of the participants in my study suggested textbooks and websites where I could find didactic materials and official educational documents that they were currently using to organise their biology classes.

For the choice of documents, I also asked both to my supervisors and other academics of the School of Education for suggestions. In addition, two papers by prominent scholars expert of Scottish education were particularly useful in order to identify official documents, institutions and their websites. One was *Citizenship in Scottish schools: The evolution of education for citizenship from the late twentieth century to the present*, by Munn and Arnott (2009). The second was *The origins and development of curriculum for excellence: Discourse, politics and control*, by Humes (2013).

The documents selected for my analysis were the following:

1) Academic articles published between 2008-2016 related to the *CfE* and its implementation
2) A series of official *CfE* documents produced by the Scottish Executive, the Scottish Government, the Scottish Executive Education Department

(SEED), Learning and Teaching Scotland (LT Scotland) and Her Majesty's Inspectorate of Education (HMIe).

3) The science and biology specifications, available online in the website of the Scottish Qualifications Authority (SQA)
4) Online resources for biology teachers published by the SQA
5) Biology textbooks

The semi-structured in-depth interviews took place between *May 2012 and June 2013*. The interviews included 16 individual interviews and two group interviews. In total, I interviewed twenty-one biology teachers. Twenty of them were working in state secondary schools, and one in a private secondary school. This teacher had two teenage daughters who were attending state secondary schools. The participants were recruited from thirteen different local authorities in Scotland. Gender, teaching experience, studies and age of the participants are reported in Appendix 3 that result from a brief and anonymous questionnaire that the participants were asked to fill in before the interviews (Appendix 2). When asked to participate in my project the interviewees were told that my aim was to investigate the role of SB in GCE. As a consequence, the teachers that accepted to participate were expected to be committed to GCE in some respect. However, I was also expecting that the nature of this commitment would vary.

I attended the interviews with twelve laminated flash cards each of which had printed a question from the interview protocol. Every time I asked a question, I placed one card in front of the respondent for the time he or she took to answer the question. In this way, the participant did not run the risk both to go off topic and to misunderstand the question because of my Italian accent. In asking the questions, I tried to follow the same order during all the interviews. However, as the interviews developed, the participants were relatively free to move to topics of their interest. In a few cases, either because a participant had already answer to a given question or because the flow of the interview had anticipated issues and themes, I varied the scheduled order of the questions.

As my research involved people, ethical considerations were particularly important. Therefore, I first carried out a mini literature review on the issue of the ethical consideration in qualitative research including the Revised ethical guidelines for educational research edited by the British Educational Research Association. Secondly, I carefully read the ethical guidelines of the University of Glasgow. Hence, I submitted the application form for ethical approval to the College Ethics Committee for Non-Clinical Research Involving Human Subjects of the University of Glasgow.

After I was granted permission by the committee, I identified, the people responsible for selecting research projects in the schools in each of all the Local Educational Authorities of Scotland by searching through the Local authorities' websites. In the early phases, the role of my first supervisor was crucial. I approached all these individuals by means of emails (appendix 4) to request permission to identify possible participants for my research. In the email, I explained that I was an Italian secondary school science teacher, studying for a PhD in Education at the University of Glasgow and that my study included an empirical phase consisting of interviews to secondary school biology teachers. Where possible, I attached to the email, a Word file with more detailed description of my project. As a result, I was granted permission to research by twenty-one Local Authorities.

Where permission had been granted, I approached the head teachers of more than two hundred Secondary Schools either by letter or an email (Appendix 5) to request access for participation from volunteer individual Biology teachers. In the letter, beyond summarising the project, I highlighted that I had the ethical permission from the University of Glasgow for carrying out my research and that I had been given the permission by the office of Education of their local authority for contacting them. In addition, I attached the interview protocol. Where I had been given the head teacher's permission, I emailed all the biology teachers of the schools in order to ask them if they were willing to participate in my project. Fifteen biology teachers accepted my invitation. Four additional teachers from two different schools offered their participation when I was interviewing one of their colleagues. The private school teacher was recruited through the mediation of an academic of the School of Education of the University of Glasgow.

All this complex process guaranteed that my intervention was not invasive in the life of the people I was going to contact. Having been granted withe permission by the Ethical Committee of my University, from the responsible person of the Local Authority and the Head Teacher, the biology teachers approached could feel in a safe research environment. In addition, the development of the interview protocol with my supervisors and other PhD researchers and the following piloting had avoided that potential lack of sensitiveness that could pervade the protocol interview. Moreover, being myself a secondary school science teacher my purpose as an interviewer was also to attempt to create a formal and safe atmosphere where the participants had the feeling to talk with a peer, a colleague determined to learn from them.

A further ethical consideration I made was that the life of teachers is very busy and time is always short. In addition, I was also aware of the effort required when being interviewed by a colleague "investigating" one's own work. The answers given in the interview could be considered potentially threatening. My main concern was that especially the second part of the interview could cause distress and anxiety because of the politically sensitive topics relating to race and gender. Conscious of these issues, after designing the structure of the interview protocol, I piloted it with a young biology teacher in his provisional year who had been a master student supervised by my second supervisor. The main purpose of the small pilot interview was to address issues related to reliability and validity. However, a purpose of the pilot interview was also to establish possible bed of anxiety or uncertainty. From the pilot study, no changes were made to the protocol.

If uncertainty is perceived about how information is used, participants can experience anxiety and distress (Ashley, 2012). Therefore, I provided the potential participants with adequate information about the nature of the project and about how information would have been used and reported. I was quite clear in explaining that I would pay special attention to guarantee confidentiality and anonymity, specifying how I would have handled and how I would have stored the information they were providing.

In addition, I highlighted that they had the right to withdraw themselves from the study at any time, for any reason, without the need to provide me with any explanation. Moreover, before starting the interview, I asked the interviewee to read careful the Plain Language Statement and to read and sign the Consent Form.

As I already mentioned, in two schools I had the unexpected chance to interview two additional teachers in a group interview setting. When I went in the first of these two schools, the teacher who positively replied to my request and who happened to be the chief of the science department, asked me if a less senior biology teacher and a biology teacher student could participate with her in a group interview. Given the difficulty to recruit volunteer participants for educational research it was difficult for me to reject this offer. I was however aware that this may add variables in my study. Rather than a real group interview, I simply asked each teacher to discuss each question, changing the order of the respondent at every question. In the other instance, after interviewing the volunteer I had originally recruited at that school I was introduced to other two biology teachers who offered to participate in my research. This interview was more difficult to control, as the two teachers demanded more freedom in the discussion, showing that they were not comfortable with me sticking to a rigid protocol interview. This interview took the form of a small group discussion.

In my research design, I planned only individual interviews because this method, compared to group interviews, seems to be a more effective technique in idea generation (Fern, 1982). Research seems to indicate that, on average, participants in group interviews generate only 70% of the ideas generated by participants in individual interviews (Fern, 1982). Group interviews are useful research tools to address issues that cannot be adequately investigated through individual interviews. This did not seem to be the case for my research questions. In addition, when the research issues involve sensible feature, one can be inhibited in disclosing his or her own idea in the presence of other participants. This may have happened in the first group interview I held. The presence of the head of the biology department during the interview might have influenced the other two participants, especially the young teacher in her probational year.

However, the choice to include these two small group interviews in my study was also motivated by my plan to perform a phenomenographic analysis of the information collected. The purpose of a phenomenographic study is to identify different possible conceptions rather than establish what different individuals think about the topic investigated. Therefore, I thought that by increasing the number of the interviewees I would maximise the possible variation in conceptions and increase the chance of gathering the all range of possible conceptions about the topic I was investigating. Hence, I took the opportunity to listen to the voice of more people in the name of a greater variability even if this subverted a little bit the research design.

In addition, group discussions are not without advantages. The main advantage is that data is provided by the interaction among interviewees and thus, they provide insights into how a group of people construct a meaning. This interaction “offers valuable data on the extent of consensus and diversity among the participants” (Morgan, 1996: p.139). I thought that this feature could be advantageous for my phenomenographic approach. In fact, within the phenomenographic approach, the different conceptions about an aspect of reality are not something “prior to the interview, ready to be read off” (Marton cited in Orgill, 2012: p.260). Rather they are aspect of the participant awareness that the situational context of the interview allows to be reflected through a mutual understanding of the experience between two people (originally the interviewer and the interviewee).

As the phenomenographic approach investigates the variance in conceptions of a phenomenon in a group of people, data collection is supposed to continue until no new ways of understanding the phenomenon seem emerge from the analysis of the sample. Therefore, I started the analysis after the third interview and after the eleventh interview there seemed to be a reasonable number of conceptions. As from the eleventh to the twenty-first, no new conceptions appeared, I was convinced that the sample size was sufficient for my study.

All the twenty-one participants provided me with the permission to digitally record the interview. Each interview lasted on average fifty minutes and took place in the participants' school.

3.5 Approaches to Document Analysis

Document analysis is a research method consisting of a systematic review or evaluation of both printed and electronic documents in which qualitative data, including written words and images, are interpreted to become empirical knowledge. Overall, the analytical process entails "finding, selecting, appraising (making sense of), and synthesising" (Bowen, 2009: p.28) the texts contained in the documents.

This research approach has a number of advantages compared to other qualitative research methods and only a couple of drawbacks, rather than real disadvantages. Drawbacks include firstly the fact that the documents analysed are not the production of the research process itself and therefore cannot be expected to answer the research questions in an exhaustive way. Secondly, organisations and institutions may make available only the documents that are aligned with the policies, the procedures and the agenda of the organisations' principals (Bowen, 2009).

However, document analysis offers advantages that outweigh the limitations. First, compared to other qualitative research methods, it is less time consuming, as it requires only data selection, rather than data collection. In addition, documents are quite often available in the public domain. For instance, the documents I analysed were all easily available through internet, including the textbooks. Consequently, document analysis has clear cost-effectiveness benefits.

A further quality of document analysis is that documents are virtually unaffected by the research process, as the researcher is not involved in their production. This make the documents a source of stable and non-reactive data unlike, for instance, the social interactions of interviews. The independence of the text from the researcher makes the document a 'social fact' (Atkinson and Coffey, cited in Bowen, 2009), produced, shared, and used in socially organised ways.

Finally, the exact references and details in the documents and their coverage of long span of time and many settings make documents advantageous in the research process (Bowen, 2009).

As I mentioned, this method requires both examination and interpretation. Operatively, in the iterative process of examination of the documents, I combined elements of both content analysis and thematic analysis. However, I did not engage in any quantitative analysis. This choice was motivated by the fact that my interest was focused more on the ideological content of the curriculum, rather than on aspects of textual forms.

Therefore, I excluded the quantification typical of conventional content analysis. Rather, the content analysis of my study consisted in a first document review with the purpose of identifying pertinent information. In other words, I conceptualised content analysis as the process of organising fragments of the documents into categories related to the overarching research questions (Bowen, 2009). The thematic analysis was interpreted as the process of pattern recognition within the data, with the purpose to uncover themes pertinent to my study (Fereday and Muir-Cochrane, 2006).

In summary, I first read and reread the documents to get a sense of the texts and to identify possible data of relevance. I attempted to identify any citizenship or societal ideas embedded in these texts and how they were connected to school biology concepts. In this way, I selected excerpts and passages from the documents. Secondly, I coded the fragments of the texts that, in my view, described aspects of the interplay between school EB and global citizenship. Thirdly, I used concept maps to examine connections between CE and EB themes. Periodic discussions with my supervisors and other PhD students helped looking at the data from multiple perspectives and interpretations. This process was meant to guarantee objectivity and sensitivity. By objectivity, I mean the representation of the research material fairly, and by sensitivity, I mean the reactivity even to subtle cues of meaning.

Elements of content and thematic analysis were very useful in identifying pertinent data and patterns of data in the selected documents. In the second phase of the document analysis, interpretation, I followed Luke's ideologic/semantic analysis of textual narratives.

Luke develops a semantic analysis approach that enables provision of an account of the relation between the linguistic structure and ideological content. He maintains that the structure of a text can "render reading a delimiting and constraining, and thereby ideological activity" (Luke, 1989: p.53). Luke argues that curricular texts and educational contents entail coded information that have the pedagogical end to transmit a selective tradition of values, knowledge, beliefs and understanding. This is made possible by the linguistic structure characterised by lexical choices, syntactic structures and choice of topoi. Therefore, the analysis of the curricular texts independently of judgement about their ideological content hides the privileged status of the educational texts in the transmission of ideological messages to teachers and students.

Research shows that partisan representation of factual data, the intentionally selective version of a phenomenon, the didactic messages conveyed by selection of theories and omission of others can be vehicles of cultural hegemony and show that curricular knowledge is part of a complex and often contradictory process of socialisation. This process of cultural selection consists of cultural and economic initiatives of specific organisations and institutions and their social interests (Luke, 1989).

Therefore, from such a point of view, it would be naïve to omit from the analysis of educational documents and school textbooks the ideological component, as this would imply that educational systems could really transmit culturally unbiased information. Significantly, Eco offers a definition of semiotics as "the discipline studying everything which can be used in order to lie. If something cannot be used to tell a lie, conversely it cannot be used to tell the truth: it cannot in fact be used 'to tell' at all" (Seiter, 1992: p.9). In fact, "to see texts in putatively disinterested scientific terms is a patently ideological position in itself" (Luke, 1989: p.58).

Therefore, Luke suggests a form of ideological/semantic analysis of narratives that links form and content and that considers linguistic structures as a medium for the transmission of socio-cultural messages. To put it in Eco's words, Luke's document analysis aims at disclosing how words 'dictate interpretation' (Eco, 1979 cited in Luke, 1989: p.58) and how lexical selection and syntactic structure produce messages and induce the reader's response.

In addition, considering education as the transmission of a selective tradition, school curricula are an "expression of a linguistically constructed and expressed "consciousness", necessarily selective and partial and, by virtue of that selection, potentially distorting of cultural knowledges, traditions and beliefs" (1989: p.59). Accordingly, school curricula with other socialising institutions, such as family and church, can generate a particular kind of readership and the acquisition of selected understanding of the world, values and beliefs. From such a point of view, curricular texts are viewed as schematic structures coding ideological worldviews, "inviting some readers while deterring others; juxtaposing, selecting and valorising some world structures while denigrating, negating, mystifying and omitting others" (Luke, 1989: p.66).

Therefore, the purpose of the document analysis of my study was to disclose the textual narratives embedded in the *CfE* that concerned teaching EB for educating to GC, through identifying the structures of the texts in the educational documents and in the textbooks that encode ideological views. In doing so, I followed Luke in using Eco's structuralist approach. This consists in the distinction between *open* and *closed* texts and in the examination of the ideological forms of the narratives in the educational documents and in the textbooks.

Eco (1979) argues that the interpretation of the text by readers is not independent from the text itself. On the contrary, the interpretative options are generated by the structure of the text. Eco sustains that textual narratives are social constructions entailing multiple possible worlds. This is an intrinsic property of texts: the capacity to present an imaginary context that differs from the situations of both the author and the reader (Luke, 1989). Olson (cited in Luke, 1989) maintains that sentences are recipes for constructing possible worlds and texts reflect not the unitary projection of a single world, but rather a layering of possible worlds. In addition, possible worlds are ideological construction and they are neither purely the psychological construction of the reader, nor are they ontologically given. Rather, they are cultural constructs that can be analysed structurally (Luke, 1989).

Eco's structuralist approach sees semantics at the level of discourse and aims to show how certain kinds of text can induce a limited and predetermined response (Luke, 1989). The distinction between open and closed texts offers an analytical device for understanding how a text can prescribe and delimit its own interpretation. Therefore, in my research, a task was to understand if the texts of the analysed documents could constrain teachers and students to certain interpretation, rather than others.

In closed fictional texts, the author invites the readers to forecast, but, at each step of the plot, he or she manifests without ambiguity what has to be taken as true in the fictional world: "The reading of a closed text simply entails the matching and testing of hypothesis against the serially disclosed information of the text" (Luke, 1989: p.70). In closed texts, the narrative is driven in a series of causal chains and the systematic elimination of alternatives, simplification, reinforcement and reiteration draws towards a single unitary correct message. In short, closed texts tend to encourage a single interpretation.

In contrast, open texts can be freely interpreted and cooperatively generated by the reader. From this point of view the text is incomplete without the interpretation of the reader. To be completed, the text needs the cooperation of the reader who has to fill the gaps through his or her inferential activity. Most of the information is implicit and therefore a text is also made of unsaid. Therefore, the reader is supposed to extrapolate such information, according to his or her skill and knowledge of the communicative context. An open text is “a paramount instance of a syntactic-semantico-pragmatic device whose foreseen interpretation is a part of its generative process” (Eco, 1979: p. 3). Consider, for instance, the Baudelaire’s poem *The Chats* (appendix 6). In the poem, there is a semantic affinity among *Erebus*, *horror of darkness* and *gloomy steeds*. In fact, in Greek mythology, Erebus was a deity representing the personification of darkness. However, the semantic affinity is not an explicit manifestation of the text. Readers of an open text are called for cooperation and have to actively make a series of interpretative choices.

Therefore, open texts are structured in a way to allow the reader to make a number of interpretations, through the implicit and the incompleteness of the text. Closed texts attempt to lead the reader to a specific interpretation. As a matter of fact, Eco (1979) admits that the process of interpretation of a text in general requires the cooperation of the reader. In fact, any text includes anaphorical elements that require the cooperation of the reader. However, closed texts are those that aim to elicit a precise response on the part of the readers. The author of a closed text seems to assume that the interpretation of a text will be made possible on the basis of a code shared by both the author and the reader. Within Eco’s model, texts are interfaces between authors’ and readers’ worlds that readers approach through existing knowledge and competence. Opening texts enable the elaboration, reconsideration and extrapolation of readers’ prior knowledge. In contrast, closed texts “can enable a closing – a restriction, delimitation, simple reinforcement of prior knowledge, conventions, and ideological beliefs” (Luke, 1989: p.68).

The implications for the analysis of the educational texts are relevant. Describing text in terms of its closed semantic structure might provide assistance in curricular revision and in the critique of distortion and hegemony in textbooks

(Luke, 1989). Therefore, the document analysis of my study consisted substantially in attempting to reveal, in the educational documents and in the textbooks, their ideological character; the EB narratives; the textual omissions, simplifications, constraints, lexical sequences and redundancies; the possible boundaries leading to univocal interpretations; the distorted communication precluding possible interpretation. In short, with the document analysis by disclosing open and closed texts within the educational documents and textbooks, I attempted to understand what kind of reading the structure and the narrative of the texts delimits and generates.

3.6 Phenomenographic Analysis procedures

Phenomenography is a research approach originally developed, in the 1970s in Sweden, to address teaching and learning issues, in particular for describing the perceptions of learning (Orgill, 2012). The word phenomenography originates from the Greek words, *phainomenon*, meaning appearance, and *graphein*, meaning description. Phenomenography aims at identifying, describing and categorising "different understandings of reality" (Marton, 1986: p.28), that are the different ways participants understand and interpret a certain phenomenon (Sin, 2010). Such different ways of understanding a phenomenon are said conceptions, which are the units of investigation in phenomenographic analysis. This approach typically focuses on the variation in conceptions within a group of people, rather than giving detailed description of individuals (Orgill, 2012).

Phenomenography starts from the premise that in a group of people, generally, there is a variation in conceptions about a certain phenomenon. The number of possible conceptions is however limited. Phenomenography is a kind of "research which has at its aim [sic] the finding and systematising of forms of thought in terms of which people interpret significant aspect of reality" (Marton, 1981: p.177). It is an inductive approach (Thomas, 2006) that often uses semi-structured interviews with the aim to capture and describe as faithfully as possible the representations of people conceptions (Kelly, 2002). As phenomenographic analysis results in a classificatory system of the ways a group of people's conceives a phenomenon, its findings are valid when the produced classificatory system is a faithful representation of participants' stated conceptions and are reliable if a researcher can use the same classificatory system with similar sample of people (Kelly, 2002).

During the 1990s a critical discussion took place among scholars that was focused on the issue of the nature of the unit of description in phenomenography (Marton and Pong, 2005). Marton claimed that the way of describing a way of experiencing something reflected the "internal relationship between the experiencer and the experienced" and it reflected "the latter as much the former" (Marton, 1995 cited in Säljö 1997: p.175). This rather strong ontological position drew critical attention from other phenomenographers and scholars. Säljö (1997), for instance, argued that, in interview situation, social scientists have access to only utterances from interviewees. Säljö warned against considering such utterances as directly reflecting ways of experiencing a phenomenon.

In fact, a phenomenon is something that the researcher has to infer, rather than to observe in the data. In addition, interviewees' utterances could indicate ways of talking, in specific situations and for a variety of pragmatic motives, rather than ways of experiencing a phenomenon. As we have access to only people's talk, "issues of communication, language and meaning are primary in many respects when deciding on what is meant by what is said" (Säljö 1997: p.177). The critical discussion ended with Marton admitting that "now, it is perfectly clear that conceptualising is not identical with [sic] experiencing" (Marton and Pong, 2005: p.336).

The process of transcribing the recorded interviews and of interpreting and analysing the interviews of my study was a time-consuming process. The first phases of the analysis consisted in elements of content and thematic analysis. After each interview, I approximated themes inspired by the participants during the conversation. During the transcription of the first interview, I took note about main themes. However, as the process was very slow, from the second transcription I opted to simply highlight the transcribed sentences that were inspiring a theme. After each transcription, I re-listened to the interview, and read many times from multiple perspectives my transcription to identify themes, marking and segmenting the transcripts.

After the third interview (i.e. teachers 1-5), I started with the analysis of questions 1a and 1b, training myself in the use of NVivo. I made codes for these two questions, from the earlier hand-coding. Further themes emerged during this phase: so, if for example I became aware of a new theme reading the transcript of the interview with teacher 4, I went back from the start and I re-read the transcripts for teachers 1, 2 and 3 exclusively to verify possible connection with this new theme. In this way, I coded questions 1a, 1b and 3a in NVivo. After this phase, I started to compare and to contrast the responses of teachers for these tree questions and I prepared a mini-presentation about this first analysis that I presented to my supervisors. As the themes that emerged received positive feedback by my supervisors, I encoded, in the same way, questions 2, 3b and 4 in Nvivo. I then compared and contrasted teachers for those questions.

During this stage of the analysis I was reading key literature papers looking for ideas. A mini-presentation focused on the analysis of the first four questions helped me to understand where I was so far. I started with comparing the time used by teachers to answer each question, the time of the interview, the number of themes I had identified for each interview and in the two group interviews, the time used by the individual teachers. Finally, I found all these attempts to conduct quantitative analysis, as well as the use of NVivo fruitless.

Accordingly, I ultimately decided to start the phenomenographic analysis without the use of NVivo. Focusing on the first research question, I clustered in groups the numerous themes that had emerged from the multiple readings. I identified different passages of the transcripts that were, in my view, logically related. In this way, I obtained a limited number of potential conceptual categories. Phenomenographers define *categories of description* (Orgill, 2012) the categories formed by identifying clusters in patterns of of thinking. I attempted first definitions of these categories, hoping to identify different conceptions.

In my study, the conceptions emerged because there were a sort of subcategories consisting in ways of thinking or ways of talking logically related. Phenomenographers call these subcategories of description *attributes*. For instance, a quotation in which the participants made a link between teaching biology and the issue of unequal access to vaccines in the world was clustered in a different category form a quotation in which a participant linked school biology to environmental issues. In other words, the analysis seemed to show patterns in variation. With further readings, I searched for other attributes that could identify and support the emerging categories-conceptions. At each reading, I modified and tested the categories, until both the emerging categories-conceptions and categories-attributes seemed to stabilise.

In a second stage, I analysed each conception in the light of what phenomenographers call the *referential aspect* and s*tructural aspect* of a conception. Marton and Pong (2005) consider a conception consisting of two elements: the referential aspect, that is the overall meaning attributed by a person to a given phenomenon, and the structural aspects, that is what the person focuses on.

For instance, price can be given either the meaning of something inherent to the value of the object or something reflecting market conditions. The people who give, as referential aspect, the former overall meaning, focus on features of the objects on sale, such as the material they are made of, their aesthetics, their quality, and so on. This consists of the structural aspect of such conception of price. Conversely, people who associate the meaning of price to market conditions tend to focus, when they talk, on the demand of those who buy the object and the supply of the object itself. This is the structural aspect of the latter conception of price (Marton and Pong, 2005).

Finally, in the third phase of the analysis, I explored the structure between attributes of each conception and among different conceptions. I logically related these categories of descriptions between them in a conceptual map that phenomenographers call *outcome space* (Orgill, 2012). The outcome space provides a “collective anatomy of awareness” for a phenomenon (Säljö 1997: p.179).

In the construction of the outcome space, I followed Marton's and Booth's criteria (reported by Åkerlind, 2012) that are as follows: each category in the outcome space must reveal something distinctive; categories must be logically and hierarchically related; outcomes must be parsimonious – i.e. the variation in understanding observed data is represented by a set of as few categories as possible. Therefore, when I was sure to have a number of stable categories I created an outcome space where the categories were ordered from the simplest to the most complex, in a way that, as in any hierarchical taxonomy, the most complex category included all the others.

Table 3.1 is a summary of the meaning of the key terms in phenomenographic analysis.

Categories of description in the phenomenographic classificatory system	
Category of description	Either a logically assemblage of quotations to form an attribute or a logically assemblage of attributes to form a conception.
Conception	One of a limited number of ways of understanding, perceiving, conceptualising a certain phenomenon, within a group of people. A conception is a researcher's construction through the logically assemblage of different, but related, attributes.
Attribute	It is a smaller category of description. Logically assemblage of quotations, that is clustered with related attributes, to support the existence of a conception.
Referential aspect	Overall meaning of a conception.
Structural aspect	What is focused on when a phenomenon is described.
Outcome space	Hierarchical relationship among categories of description.

Table 3.1: Categories of description in the phenomenographic classificatory system

Chapter four: Review and Analysis of the Documents

4.1 Chapter overview

The empirical research for my study was conducted within the educational context of the implementation of the new national curriculum in Scotland, the so-called *Curriculum for Excellence*. CfE is described as "one of the most ambitious programmes of educational change ever undertaken in Scotland" and aims to equip young people "with the skills for passing the exams, and skills for learning, skills for life and skills for work" (Scottish Government, 2008: p.8). In this chapter, I first provide an overview of the *CfE* citizenship education context (section 4.2). Secondly, I address the issue of the relevance of the curricular SB/EB framework for GCE in compulsory secondary schools in Scotland (section 4.3). I conclude with section 4.3 by illuminating the findings of the ideological and semantic analysis of the biology textbooks directed at the fifteen-sixteen years age group, in order to explore the link between EB and GCE emerging from the textbooks.

4.2 The Citizenship Education curricular context and its relationship with the biology/Evolutionary Biology framework within which biology teachers are acting

In this section, I first outline the role of the main educational official documents in the historical development of the CfE in order to explore the CE context embodied in the CfE. Secondly, I investigate the biology teachers' expected role in CfE CE. Finally, I critically review the biology progressive framework in order to understand to what extent the biology specifications in general, and the EB specification in particular, contribute to GCE.

4.2.1 Citizenship Education curricular context

The process of the new curricular reform in Scotland has its roots in the National Debate on Education, an extensive consultation on the state of school education, promoted by the Scottish Executive in 2002 (Humes, 2013). The process of change was developed over eight years and implemented in 2010. The first official document was published in 2004 by the Scottish Executive (now Scottish Government). The publication consisted of the report of the so-called Curriculum Review Group, established in 2003 (Scottish Executive, 2004), accompanied by the Ministerial response. In 2005, the main organisation for the development of the new curriculum, Learning and Teaching Scotland (LTS), promoted research consisting of focus groups made up of practitioners from around the country in order to develop simpler curriculum guidelines. This resulted in the publication in 2006 of *Progress and Proposals* (Scottish Executive, 2006a) which articulated in a clear and more detailed way the key features of the new curriculum. These included the involvement of teachers in the process of change, the centrality of learning and teaching, and the unification of teaching for the age groups 3 to 18 (Priestley, 2013).

Since 2006, a series of documents were published called *Building the Curriculum* which aim at providing guidance on different aspects of the curriculum. These documents encountered criticism for their lack of clarity and focus (Priestley, 2013). *Building the Curriculum 1* (Scottish Executive, 2006b) focussed on the contribution of each of the eight curriculum areas (i.e. expressive arts, health and wellbeing, languages, mathematics, religious, science, social studies and technologies) in order to help teachers to identify ways of developing collaborative and interdisciplinary learning and teaching activities with the final aim of reflecting the four capacities (i.e. responsible citizens, effective contributors, successful learners, confident individuals). *Building the Curriculum 2* (Scottish Executive, 2007) provided an overview of active learning for learners in early years, while *Building the Curriculum 3* (Scottish Government, 2008) provided the framework for planning a curriculum. *Building the Curriculum 4* (Scottish Government, 2009a) was intended to support planning, design and delivery of the curriculum. *Building the Curriculum 5* (Scottish Government, 2011) provided guidance for assessment strategies.

From 2007, a draft of the experiences and outcomes, defined as “the national aspirations for every young person” (Scottish Executive, 2006b: p.5), started to be published. These were subjected to feedback from practitioners which was in turn analysed by the University of Glasgow (Baumfield et al., 2008). In 2009, the new curriculum guidelines were published for implementation (Scottish government, 2009b) and from August 2010 schools began to deliver the CfE. In addition, students started to study for the new qualifications (i.e. National 1 to 5) that were part of the curricular reform and that were replacing Standard Grade, Intermediates and Access qualifications (DERA, 2013). In 2014 and 2015, new Higher and Advanced Higher qualifications were respectively introduced to complete the secondary studies.

The new Scottish national curriculum has been designed to provide a single coherent curriculum for all young people aged 3-18 (Day and Bryce, 2013). From pre-school to S3, students are entitled ‘to broad general education organised around experiences and outcomes in eight curricular areas but with an emphasis on inter-disciplinary learning’ (DERA, 2013: p.3). S4 signals the beginning of the so-called *Senior Phase* during which students take qualifications and this can continue either to S6 or to *further education* in college. As biology and science are not compulsory after the age of majority (age of 16 in Scots law), this research focuses on the first four years of secondary school (S1-S4) which mark the end of compulsory secondary school education.

The new national curriculum of Scotland has attracted attention around the world for its innovative and radical structure focused on the notion of four capacities which are intrinsically linked to CE, for its emphasis on interdisciplinary and active learning, and for engaging teachers as agents of change (Priestley, 2013). Therefore, CfE seems to be in line with the Scottish educational tradition of considering citizenship a core purpose of school curricula (Munn and Arnott, 2009).

CfE exhibits several significant features connected with CE and GCE. For instance, in the *A Curriculum for Excellence*: *The Curriculum Review Group* (Scottish Executive, 2004), it is argued that social responsibility is not only dependent on the values on which Scottish society is based but also on the need to “help young people to understand diverse cultures and beliefs” (p.11). In addition, the Scottish societal values invoked include justice and compassion, which are two of the words inscribed on the mace of the Scottish Parliament (the others are wisdom and integrity). It is not the purpose of this study to verify if the Scottish society is indeed based on these values. However, at least at a rhetoric level these claimed values have important implications for CE. In fact, as I illustrated in the literature review, justice and compassion are key words in the cosmopolitan philosophies and compassion is the central principle underlying the Euripidean strain of cosmopolitan education (Nussbaum, 2003).

CE is also embodied in the claimed educational purpose of developing in young people the abovementioned four capacities. These consist substantially of responsibility (responsible citizens), confidence (confident individuals), functional learning (successful learner) and resilience (effective contributors). The four capacities are all directly related to how an individual can be a citizen in a democratic society. For instance, among other things, to be successful learners students have to show “openness to new thinking and ideas”; to be confident individuals they must be able to “relate to others and manage themselves”; to be responsible citizens, students must “understand different beliefs and cultures”; and in order to be effective contributors they must be able to “work in partnership and in teams” (Scottish Executive, 2004: p.12). However, critical observers have argued that these capacities tend to become broad slogans, rather than being aspirational goals of the CfE that are realisable in practice (Priestley, 2013).

Beyond the four key capacities that students should develop, the *CfE* assigns to CE a central role by suggesting pedagogical approaches and by promoting values in this direction. For instance, these are the adoption of an integrated and interdisciplinary approach to citizenship education; the engagement of the educational system in promoting democracy and social justice; the promotion of respect towards different cultures; the acknowledgement of the rights and the responsibilities of individuals in society.

A key element in helping students recognise themselves as global citizens is the appreciation of the common values and principles of education for citizenship, international education and sustainable development education (Learning and Teaching Scotland, 2011). Such common values determine a number of expected educational objectives which include, for instance, the promotion of the concept of shared humanity; the development of empathy and the awareness of rights and duties at regional, national and global level; the development of literacy (e.g. political, scientific, economic and financial literacy) in order to empower learners with knowledge that enables them to take informed decisions and responsible actions at local and global levels; and the promotion of the awareness of the possible impact that prejudice and discrimination can have in school as well as in wider society (Scottish Executive, 2004).

Therefore, in theory, the curriculum suggests an integrated approach to developing responsible global citizenship that is not an ‘add-on to Curriculum for Excellence, [but] it is central to it’ (Learning and Teaching Scotland, 2011: p.5). The attributes, knowledge, skills and values necessary for responsible global citizens should be developed in learners by means of a co-ordinated whole school approach. As a consequence, across all eight curriculum areas, students are supposed to learn ‘through global context about a globalised world for life and work in a global society’ (Learning and Teaching Scotland, 2011: p.10).

4.2.2 Teachers as agents of change

A key theme in the CfE policy is the combination of a flexibility of schools with the view of teachers as the agents of change in the processes of integration of top-down government directions with bottom-up school-base approaches (Priestley, 2010). Flexibility, in theory, entitles schools to develop content and pedagogy in order to meet needs of individual learners and local communities. Schools have, in fact, “freedom and responsibility to meet the needs of children and young people in their local communities […] [and] national guidance needs to support a flexible approach which meets local needs and changing circumstances” (Scottish Government, 2008). This means that teachers are asked to work between the invoked flexibility for schools and the need to guarantee national standards. In this, teachers are considered the ‘key to successful implementation of *A Curriculum for Excellence*’ (Scottish Executive, 2006a: p.1).

As flexibility can make the implementation of the contents necessary for the national qualifications difficult (Priestley, 2013), teachers are asked to interpret ‘creatively and flexibly’ (Scottish Executive, 2004: p.10) the curricular arrangements in order to raise levels of achievement for students. In such a framework, in theory, it would be difficult to, for instance, propose the kind of pedagogy that Freire defines as *banking education* (Freire, 2007: p72), that is the pedagogy in which information is understood to flow passively from teachers to learners. In fact, the expected outcomes as presented in a section called *experiences and outcomes* make clear that what is expected to be achieved is first and foremost a learning experience. In addition, the explicit purpose of making learning active, challenging and enjoyable, and of assuring assessment which supports learners (Scottish Executive, 2004) have profound implications for the teaching approaches to be adopted, the environment for learning that teachers have to create and the ways in which learning is organised.

Teachers are explicitly requested to create a learning environment in which learners are supposed to be inspiringly engaged and actively asked to draw and to express their own conclusions (Learning and Teaching Scotland, 2011). They are asked to plan learning activities in a way that learning processes occur through a variety of contexts both within the classroom and other aspects of school life. In addition, the purpose of building ‘independent, creative and critical thinkers to develop informed views and to act responsibly in our modern world’ (Learning and Teaching Scotland, 2011: p. 12) entails a deep commitment to an interdisciplinary approach. “Taken as a whole, the experiences and the outcomes embody the attributes and the capabilities of the four capacities. They apply to the totality of experiences which are planned for children and young people, including the ethos and life of the school and interdisciplinary studies as well as learning with curriculum areas and subjects" (Scottish Government, 2009b: p. 3).

The educational documents encourage teachers to use a variety of approaches and the promotion of experiential learning, drawing on the local natural and built environment for studying the big ideas of science. Science/biology teachers, and likewise their colleagues, are supposed to have 'freedom to teach in innovative and creative ways' (Scottish Executive, 2006b, p.16). Suggested approaches for science teachers include: the use of problem solving procedures and the use of activities promoting analytical thinking; the use of scientific inquiry learning; contextualising science in the everyday students' experiences; using technologies and materials in appropriate ways (e.g. safety and sustainability); facilitating collaborative learning and using activities for promoting independent thinking; and helping students to express their own opinions and to participate as informed individuals in class discussions. In addition, the curriculum suggests the use of open-ended learning experiences which means to emphasise in science classrooms the process of scientific inquiry rather than scientific truths.

Teachers are directed to plan investigations, inquiries, challenges and more detailed and comprehensive activities in order to develop the attributes of scientifically literate citizens. These attributes are: manifesting respect for evidence; respecting other living beings and environment; evaluating benefits and possible risks of the applications of science; making informed choices; understanding media reports on science; reflecting critically on information; developing opinions on and actively participating in the debates on socioscientific issues; communicating democratically one's opinions; and understanding the impact of science on individuals and society. In addition, teachers are asked to allow students to work collaboratively, sharing tasks in simulated real-life situations and to promote effective partnership in a locally relevant context (SQA, 2013d). Science teachers are also expected to include features of assessment in science that are related to citizenship education. These consist of investigating the extent to which students acknowledge the impact of science on individuals, society, the environment and the economy, and the extent to which they link science with other areas of the curriculum and the world outside the school.

To summarise, the main stated features of the educational environment in which teachers are asked to work are related to flexibility, pedagogy and the organisation of knowledge. The flexibility is supposed to be provided by the experiences and outcomes framework as it “allows for both professional autonomy and responsibility when planning and delivering the curriculum… The framework provides flexibility to organise, schedule and deliver the experiences and outcomes in ways that meet the needs of all learners, but also provides reassurance about consistency where necessary. Such flexibility will result in a more varied pattern of curriculum structures to reflect local needs and circumstances” (Scottish Government, 2008: p.11).

The pedagogical innovation that teachers, as main actors, are asked to implement consists of cooperative learning, formative assessment, problem-solving approaches, active learning and techniques allowing students to explain their understanding of concepts, informed discussion, and communication (Scottish Government, 2009). Therefore, the role of the teachers is not the *banking* transmission of content and knowledge. Rather, it consists in the professional ability to creatively provide those learning conditions that allow individual students to be more responsible for their own learning. For instance, in the curriculum it is claimed that “the sciences experiences and outcomes are designed to stimulate the interest and motivation of children and young people and to support staff in planning challenging, engaging and enjoyable learning and teaching activities. They allow flexibility and choice for both teachers and learners to meet individual learning needs (Scottish Government, 2009b: p.254).

The organisation of knowledge is related to the cross-curricular educational themes that are considered the responsibility of all teachers. Beyond citizenship, literacy, numeracy and health and wellbeing are also considered the duty of all practitioners (Scottish Government, 2009b). In addition, within the CfE framework, many schools are implementing modular models (one teacher, more subjects) and interdisciplinary rich-task approaches in which different subjects contribute to an event such as the “Africa-themed week [that] often involves citizenship and GC’ (Priestley, 2013: p.31).

CfE has also attracted criticism and disbelief. For instance, Priestley (2010) argues that the reduction of curricular prescription results in vagueness in terms of contents and approaches, making the implementation of the CfE policy into practice difficult. He relates this perceived vagueness to the findings of a survey from one local authority (Priestley and Minty, 2012) that show that, although the main principles underpinning CfE are widely welcomed by teachers, there is also “a considerable level of discontent with the process of implementation” (Priestley, 2013: p.37). Priestley speculates that teachers’ discontent depends in part on the policies of accountability that leads them to perceive that the responsibility they are invested with in the implementation of the curricular innovation is not without difficulty and danger (Priestley, 2013).

One issue is related to the interdisciplinary approaches that have been invoked. Interdisciplinary approaches are more rooted in primary school, but in secondary education their development is more problematic (Priestley and Minty, 2012). Priestley (2013) maintains that this is related to a lack of knowledge of theories of interdisciplinary strategies. For instance, he argues that, in secondary schools, interdisciplinary approaches are sometimes artificial as they are constructed around preconceived themes, rather than starting from content that is explicitly linked to the purposes of CfE. In addition, “in the majority of the schools, there has been little attempt to change existing timetable structures” (p.31, but without references) and most of them devote the majority of the time to subject-related activities and only part of the time to fulfil their interdisciplinary and active learning duties.

A further criticism raised by Priestley (2013) is related to a supposed lack of originality of the CfE. In fact, he maintains that curricula in both New Zealand and England provide similar instances of educational settings in which the maintenance of national standards and central guidance coexist with programmes designed to also account for local and individual needs. In other words, he considers the CfE neither “terribly distinctive in worldwide terms” (p.35) nor new and radical in terms of pedagogy, because cooperative learning, which is one of the alternative pedagogies invoked, “was developed in the 1970s and has been widely used across the world since then” (p.36). However, Priestley himself admits that “it is certainly true that Scotland has witnessed the development over the last ten years of much pedagogical innovation” (p.35).

4.2.3 The Link between the Biology progression framework and Citizenship Education

In the educational context I have just depicted, I now attempt to describe to what extent the science/biology curriculum provides teachers with opportunities to examine issues that might contribute to promoting GC. The stated purposes of the CfE that are related to GCE include: the development of the awareness of the world as a single global environment and as a network of interconnections and interdependences; the promotion of living sustainably in such a global environment by contributing to a fair global society both for the present and for future generations (Learning and Teaching Scotland, 2011). In addition, science teachers working within the CfE have the responsibility of delivering lessons on issues such as global warming, deforestation and the consequences on future generations of present energetic choices.

The link between science and citizenship emerges in the very first paragraph of the stated science principles of the CfE (Scottish Government, 2009b: p.253).

Science is an important part of our heritage and we use its applications every day in our lives at work, at leisure and in the home. Science and the application *of science are central to our economic future and to our health and wellbeing as individuals and as a society. Scotland has a long tradition of scientific discovery, of innovation in the application of scientific discovery, and of the application of science in the protection and enhancement of the natural and built environment. Children and young people are fascinated by new discoveries and technologies and become increasingly aware of, and passionate about, the impact of science on their own health and wellbeing, the health of society and the health of the environment.*

From the very first lines of the introduction, the assimilation of science to technology it is thereby manifest. The focus of the introduction of the science curriculum is, in fact, on technology and the application of science within contemporary societies, rather than on science as the evidence-based system of knowledge production. Science with its applications is interpreted through the lens of its implications on individual everyday lives, on the economy, and on the health of individuals, society and the environment.

Eight of the twelve main declared purposes of learning in science are citizenship related. These are: developing interest and understanding of the natural and built environment in which one lives; developing understanding of the big ideas of science; developing skills for life and work; encouraging actions and behaviour to control risk and hazards; recognising the role of science on individuals, society and environment; promoting a sustainable use of energy; developing skills for actively participating in debates on socio-scientific issues with ethical, economic and environmental implications; promoting scientific literacy in young citizens and developing a lifelong interest in science; and establishing the foundation for possible future careers in science (Scottish Government, 2009b).

The first three years of the secondary school (S1-S3), attended by students aged 12-15 years old, is still considered a broad general education in which Science is one of the eight curricular areas and Biology is one of the five organisers of Science. Each of these five organisers (i.e. Planet Earth; Forces, Electricity and Waves; Biological Systems; Materials; Topical science) provides a range of contexts for learning related to citizenship. The organiser called ‘topical science’ deals with socioscientific issues and includes issues related to biology.

In S4, students undertake a limited number of subjects. In 2013, biology was the third “most popular subject studied by S4 when considering the proportion of pupils taking five or more courses” (Scottish Government, 2013: p.56). The subjects are labelled with the term National 3 (N3), National 4 (N4) or National 5 (N5) which indicate different study levels. A fifteen-sixteen year-old student can study biology at one of these levels. Therefore, the fourth and the fifth levels of achievement are not indispensable requirements for every learner. After S4, Scottish students can choose whether or not to study biology. If they do, they can study Higher Biology or Human Higher Biology and, then, Advanced Higher Biology.

Biology courses are hierarchical, from N3 to Advanced Higher Biology. N3 (formerly Access 3), N4 (formerly Intermediate 1+Standard Grade General) and N5 (formerly Intermediate 2+Standard Grade Credit) are “designed to allow a considerable degree of flexibility in the study of the key areas” (SQA, 2013a: p.5). Courses from N3 to N5 have Units with the same names and structures. The units are defined as “statements of standards for assessment and not programmes of learning and teaching” (SQA, 2013a: p.5).

The Courses have three mandatory Units (i.e. Cell biology, Multicellular organisms, and Life on Earth) that are designed to provide progression to the corresponding Units at the following level (e.g. the three units of the course N4 are functional for the corresponding units of the N5). N5 gives equal progression to both Higher Biology and Higher Human Biology. Higher Biology and Higher Human Biology give equal progression to Advanced Higher Biology (SQA, 2013b). Appendix 7 summarises the biology progression framework relating the key areas of the courses (from N3 to N5) to the Science Experiences and Outcomes stated in the CfE.

Courses from National 4 to Advanced Higher include a fourth mandatory Unit, the *Added Value Unit*, which consists of a Biology assignment in which students are asked to apply skills, knowledge and understanding to investigate a topical issue in biology and its impact on the environment and society. Schools have considerable flexibility in the choice of context for the assignment. However, the issue must draw on one or more of the key areas of the course, and should be chosen with guidance from the assessor. In this Unit, students are asked to "draw on and extend the skills they have learned from across the other Units, and demonstrate the breadth of knowledge and skills acquired, in unfamiliar contexts and/or integrated ways" (SQA, 2013b: p.7).

In the stated relationship between the biology courses and the *CfE* values, it is highlighted that biology plays a crucial role in the life of citizens and that its importance in everyday existence is increased in the modern world because of advances in genetics and molecular biology. In this context, a purpose of the biology specification is to contribute to developing confident individuals by encouraging the development of skills and resourcefulness. In addition, in theory, the biology specification is designed to facilitate students' success in learning by fostering their ability to think creatively to analyse and solve problems. Moreover, the biology course should develop in young people as sense of responsibility, through studying health, the environment and sustainability.

The biology courses aim at developing in students three main features useful to their life as citizens of the global society. The first is the students' skills in communication and collaboration in order to prepare them for democratic participation in society and employment (SQA, 2013a). The second is the students' skills in scientific inquiry and investigation, to be developed through the biology course in a way that students can become scientifically literate citizens and able to review biology-based claims in society (SQA, 2013a). Thirdly, the courses aim at fostering the acknowledgement that biology has an impact on our lives, on the lives of others, on the global environment and on society. With this purpose in mind, the architects of the national qualifications have included the compulsory investigation of the ethical and topical issues related to the mandatory units of the biology courses, starting from the basic N3. For instance, the outcomes 2, within the Outcomes and Assessment standards, includes "describing a given biological issue in terms of the effect on the environment/society" (SQA, 2013h).

Priestley and Minty (2012) report that during the early phases of the development of the reforms, the widely-perceived vagueness and lack of clarity in terms of qualifications had generated anxieties among biology teachers and their colleagues. Priestley (2013) ascribes these feelings to the fact that assessment is a main concern for secondary school teachers, as attainment data are systematically used by parents, local authorities, school managers and inspectors in order to evaluate school and teacher effectiveness. Therefore, it is understandable when teachers maintain that they do "not know what to teach until they know what is to be assessed" (Priestley, 2013: p.32).

In response to such anxieties, the SQA website provides information about learning and teaching resources. For instance, documents called Unit Support Notes can be freely downloaded from the website www.sqa.org.uk. These documents provide advice and guidance on approaches to delivering the mandatory units of the biology specification. In the documents, teachers find suggestions for possible contexts and learning activities, by providing each key area of each unit specification with suggested learning activities and exemplification. Table 4.1, as an instance of a biological topic correlated to CE, reports the SQA advice relating to the key area the *Role of technology in monitoring health and improving quality of life* which is part of the unit *Multicellular organisms.*

Unit Multicellular organisms		
Compulsory Key areas	Suggested Learning Activities	Exemplification of key areas

Role of technology in monitoring health and improving quality of life	Research ways to maintain a healthy lifestyle through positive lifestyle choices	Different aspects of health can be monitored using a wide variety of technological equipment. The information from this monitoring can be used to improve the quality of life of an individual

Table 4.1 Modified by the National 3 Biology Support Notes (SQA, 2013d: p.8).

From table 4.2, an interesting feature of the CfE emerges that is related to the afore-mentioned flexibility and consists of the description of the mandatory key area with an open text. The table is part of a more comprehensive table reported in the “National 3 Biology Course Support Notes” that every biology teacher in Scotland is supposed to read in order to plan his or her N3 classes. The table reports the SQA advice relating to the key area *Different types of chemicals in agriculture, the alternatives and their impact on global food production, which is* part of the unit *Life of Earth* of the biology specification. From the suggested SQA exemplification a peculiar idea of the interplay between SB and GCE emerges. In fact, the non-compulsory exemplification suggests an unquestioning confidence in the use of chemicals in agricultures. However, the wording of the compulsory key area makes the excerpt from the CfE an open text, in Eco’s taxonomy.

Unit Life of Earth		
Compulsory Key areas	Suggested Learning Activities	Exemplification of key areas

Different types of chemicals in agriculture, the alternatives and their impact on global food production	Investigate growth of seedlings with or without different types of chemicals. Research costs and benefits of modern and traditional methods of crop production. Research/visit conventional/organic food producers	Different types of chemical include fertilisers and pesticides. Alternative methods include manure and biological control. Fertilisers can improve crop yield to ensure that enough food is produced to feed the increasing population of the world. Pesticides prevent crop damages. Feeding the increasing human population requires increasing use of fertilisers and pesticides

Table 4.2 Modified by the National 3 Biology Support Notes (SQA, 2013d: p.10).

The openness of the text is manifest in the fact that the phrase “the alternatives and their impact on global food production” is incomplete and thereby, put in Eco’s words, it needs the cooperation of the reader (the biology teacher) to be completed (Eco, 1979). Teachers can complete the text with their expertise, in the same way Baudelaire’s poem, mentioned in the methodology chapter, needs to be completed by a competent reader. The flexibility of the CfE resides in this feature. In fact, what in a conventional biology specification would be presented as an expected outcome, in this compulsory key area of CfE key area is presented as an open text which can be freely interpreted by the biology teacher. He or she will be free to interpret it naïvely, as the SQA seems to suggest, that the use of chemicals in agriculture is made for “feeding the increasing human population” (SQA, 2013d: p.10). However, he or she will be free to interpret it in a more critical way and to use this piece of biology specification to open debates and discussions in the classroom for instance focusing on the research showing that, for instance, intensive conventional agriculture can introduce contaminants into the food chain (Rembiałkowska, 2007).

The openness of the texts illustrating the key areas of the N4 specifications offers obvious links with global citizenship education. These can be found, for example, in the Unit *Cell Biology*, *Therapeutic use of cells*, *Properties of enzymes and use in industries*, *Properties of microorganisms and use in industries* and *Controversial biological procedures*; in the Unit *Multicellular Organisms*, *Commercial use of plants*; and in the Unit *Life on Earth*, *Impact of population growth and natural hazards on biodiversity* and *Fertilisers design and environmental of fertilisers*.

According to The National Parent Forum of Scotland, the CfE Biology Course at National 4 level should develop a range of citizenship-related skills. These are: the acknowledgment of the role of biology in contemporary scientific issues, in society and in the environment; problem-solving skills; finding associations and investigating models in real-life contexts; using scientific literacy for communicating about the socioscientific issues; the ability to review science-based claims in media reports in evaluating environmental and scientific issues; and risk assessment and decision-making (https://www.npfs.org.uk/nationals-in-a-nutshell/)

In line with this, for instance, the mandatory key areas within the Unit *Cell Biology* includes the therapeutic use of cells with the suggested exemplification of insulin or other protein production via genetic engineering, stem cell technology and artificial organs production; properties of enzymes and their use in industries; the properties of microorganisms and their use in industries; and controversial biological procedures. Within the same Unit, the suggested learning activity includes: investigate the use of cells in the context of tissue culture for therapeutic use; investigate genetic engineering; research project or visit research labs; investigate the history and ethics of rennet production; make bread, beer, yoghurt; visit local industry; investigate production and use of biofuels; use IT simulations and data logging; investigate and debate relevant interesting topics, such as gene therapy, pharming, transgenic animals and plants (N4c). Similarly, within the Unit *Multicellular Organisms*, the topic *Commercial use of plants* is compulsory with the possible exemplifications of plant production for providing food, raw materials, medicines, beauty products and pharming in order to produce crops, fuel and pharmaceuticals from genetically modified plants (SQA, 2013e).

Similar resources for developing CE are also offered by the N5 Biology Course. For instance, the N5 Support Notes suggest researching "current genetic foods/issues such as golden rice, less toxic rape seed oil, bird resistance to bird flu, tomatoes with longer shelf life, blight resistance potatoes, production of medicines for human use e.g. insulin and growth hormone" (SQA, 2013f: **p.10**).

The CfE biology progression framework demands that teachers foster two further different aspects of CE. The first is related to the body, the second to the local, global and natural environments in which citizens live. The first is related to the purpose of promoting positive lifestyle choices in students. For instance, the biology specification includes the study of the reasons we need a balanced diet, water, minerals, vitamins and suitable conditions, along with discussions with the students on the links between diet and growth and development disorders (SQA, 2013e).

The second aspect is related to the need for sustainability. In fact, mandatory key areas include the interdependence of living beings, the impact of population growth and natural hazards on biodiversity, and suggests the study of how human population growth results in habitat destruction, deforestation, over-fishing, intensive agriculture, genetic pollution, climate change, acid rain, oil and chemical spills, sewage and litter (SQA, 2013e). In addition, the suggested learning activities include the promotion of research on ecological footprints, the debates around the negative effects of environmental disruptions on biodiversity, the need for the conservation of endangered species, and for maintaining biodiversity both nationally and globally. Along similar lines, activities are suggested that involve investigating Blue Flag beaches and the effects of fertilisers, again nationally and internationally (SQA, 2013e).

In addition, outcomes and assessments standards can be easily linked with global citizenship education. For instance, teachers and assessors working within the N3-N5 progression biology framework are requested to collect evidence from a variety of sources in order to show if a student is able to *Describe an application* and to *Describe a biological issue in terms of the effect on the environment/society* (outcomes 2.2 and 2.3). For instance, assessors are asked to investigate whether a piece of written work from a student provides evidence that “a biological issue is stated”, that “an issue is related to a key area of the Course” and that “appropriate biology knowledge is used to describe its effect” (SQA, 2013e: p.25).

Equality and inclusion practices are mentioned in the support notes in order to help students with physical disabilities, visual impairment, learning difficulties, cognitive difficulties and autism (SQA, 2013d).

4.2.4 Evolutionary biology in the compulsory secondary school Biology Framework and its relationship with Citizenship Education

In this section, I illustrate the findings of the analysis of the texts linking EB and CE in the biology framework of the official educational documents related to the CfE. The documents analysed are those relating to biology courses up to National 5 level which, as mentioned, represents the highest level of biology course that learners can achieve up to 16 years of age. In other words, excluded from this analysis are documents relating to Higher Biology, Higher Human Biology and Advanced Higher Biology because these courses involve only a minority of learners who clearly manifest a great interest in biology, rather than the majority of the population. The documents were analysed in the light of the following research questions: *Are the texts relating to Evolutionary Biology within the CfE biology framework "closed texts" (according to Eco's taxonomy) and thereby the reader (the teacher) is led to univocal interpretation? Are there aspects of EB that are prioritised, undermined or ignored? Are there omissions, simplifications and constraints in the biology framework that might induce a biased vision of EB*?

The CfE biology progression framework includes many mandatory key course areas that are related to EB. Virtually all these areas are also linked to CE. Within the N3 qualification these are: "risks and benefits of DNA profiling" (SQA, 2013d: p.6); "body defences against disease and role of vaccine" (N3c: p.8); and "identifying living things from different habitats to compare their biodiversity and suggest the reasons for their distribution" (SQA, 2013d: p.10). Within the N4 qualification these are: "controversial biological procedures" (SQA, 2013e: p.9); sexual and asexual reproduction and their importance for the survival of species (N4c: p.10); genetic information (N4c: p.10); animal and plants species depend on each other (SQA, 2013e: p.12); impact of population growth and natural hazards on biodiversity (SQA, 2013d: p.12); adaptation for survival (SQA, 2013e: p.13); and "learned behaviour in response to stimuli linked to species survival" (SQA, 2013e: p.12). Within the N5 qualification: "genetic engineering" (SQA, 2013f: p.10); "stem cells and meristems" (SQA, 2013f: p.12); "reproduction" (SQA, 2013f: p.14); "biodiversity and the distribution of life" (SQA, 2013f: p.17); and "adaptation, natural selection and the evolution of species" (SQA, 2013f: p.12).

Within the unit *Cell Biology* the following learning activity is suggested for the mandatory key area *Risks and benefits of DNA profiling*: "investigate the use of DNA profiling in forensics, paternity, archaeology, or to assess future health risks" (SQA, 2013d: p.6). Therefore, in the suggested activities the choice is to focus on the applications that position humanity at the centre. A less human-centred vision of the "benefits of DNA profiling" would be provided if the above-mentioned key mandatory area included "… and genome sequencing" and the SQA suggestion to biology teachers was to "investigate the use of DNA nucleotide sequences in forensics, paternity, archaeology and palaeontology". However, the choice of the curriculum is to focus on the legal aspects of the application of EB that are supposed to provide some sort of economic, medical or legal benefits to humanity.

The only suggested EB area not bound to economic-legal aspects is linked to archaeology. The choice of archaeology is clearly legitimate and is a case in point for the invoked interdisciplinary approach. In fact, for example, studies based on the genetic analysis of ancient Egyptian mummies have provided insights into ancient human history (Schuenemann et al.2017). However, archaeology is precisely about human history, rather than natural human history. As a matter of fact, natural human history is completely disregarded in the CfE biology specifications for the S1-S4 age range. In the same way, the contribution of EB in the understanding of human taxonomy is ignored.

The analysis of genome sequences is, in fact, possibly the most powerful means in biological taxonomy. The technique can be used, for example, to compare the degree of kinship between humans and other living beings. DNA sequences can be used to construct phylogenetic trees and other diagrams representing the relationships between different species. As a matter of fact, the specifications do not formally introduce students to tree/phylogenetic thinking at all. Within intraspecific studies, DNA sequence analysis can also be used to show that genetic variation among the so-called races is small compared with intra-racial variation. It can be used to show that the knowledge provided by DNA profiling does know allow us to consider human geographic populations as different races or ethnicities. In other words, the biology specification emphasises some applications of EB with implications in agriculture, economy and health science, but it ignores its contribution to the taxonomy of living organisms and in fostering phylogenetic thinking.

Although the text "risks and benefits of DNA profiling" is associated with learning activities focusing on economic-medical applications, it does not present any constraints to the biology teacher's interpretation. In fact, in Eco's taxonomy it is an open text. Teachers, with their knowledge, interests and creativity, can complete the "unsaid" text with an alternative vision of DNA studies that collocates our species as one among millions of others engaged in the struggle for surviving. In fact, although the analysed texts show that there are aspects of EB that are prioritised and others that are undermined and ignored, the CfE text illustrating the mandatory areas does not lead the biology teacher to univocal interpretation. Nor are there in the CfE text constraints that might induce a biased vision of EB. The text leaves the teachers with the freedom and responsibility to find a balance between different views of EB in citizenship education and the uniqueness of the classroom in which he or she operates as a biology teacher and as a citizenship educator.

Similar observations can be made about other key mandatory areas of the biology progression framework that can be linked with GCE. For instance, within the unit *Life on Earth* and the key mandatory area of *Sampling and identifying living things from different habitats to compare their biodiversity and suggest reasons for their distribution*, the word evolution does not appear either within the suggested learning activities, nor within the exemplification of the key areas. Although within the latter it is stated: "Different habitats support different organisms because the organisms are adapted to exist in the particular sets of conditions" (SQA, 2013d: p.10), the ultimate reason the organisms are adapted, which is the selection of genetically different individuals, is not explicitly mentioned. However, the text "… and suggest reasons for their distribution" allows the biology teacher to introduce in the classrooms the topic of evolutionary processes. In addition, as the exemplification of the key area states "the conditions in a habitat, e.g. light […], have an effect on distribution of the organisms" (SQA, 2013d: p.10), so the biology teacher is free to illustrate the topic with the example of darker skin pigmentation as a feature that appeared, independently, in different human populations as a response to light conditions in the environment.

The openness of the texts illustrating the mandatory areas of the biology progression framework is a feature that is also very clear in the National qualification N4. At N4 level, EB is explicitly present in the key areas of *Sexual and asexual reproduction and their importance for survival of species* (SQA, 2013e: p.10), *Animal and plants species depend on each other* (SQA, 2013e: p.12) and *Adaptations for survival* (SQA, 2013e: p.13), although many other mandatory areas allow the teacher to introduce students to evolutionary studies, for instance, “Properties of enzymes and their use in industries” (SQA, 2013e: p.7), “Controversial biological procedures” (SQA, 2013e: p.9), “Genetic information” (SQA, 2013e: p.10) and “Learned behaviour in response to stimuli linked to species survival” (SQA, 2013e: p.13). Therefore, although there are no constraints in the texts illustrating the biology specifications, two key words are also missing at N4 level: these are *evolution* and *phylogenies*.

The analysis revealed similar findings in the texts illustrating the biology specifications at N5. These texts are more detailed and therefore leave less freedom to the teacher’s interpretation. Table 4.3, which is an excerpt from the National 5 Biology Courses Support Notes, is a case in point.

Unit Cell Biology		
Compulsory Key areas	Suggested Learning Activities	Exemplification of key areas
Genetic Engineering: Genetic information can be transferred from one cell to another naturally or by genetic engineering. Stages of genetic engineering to include: identify section	Research current genetic foods/issues such as golden rice, less toxic rape seed oil, bird resistance to bird flu, tomatoes with longer shelf life, blight resistant potatoes,	DNA can be transferred naturally between cells either by bacterial plasmids or viruses. Details of these processes not required.

of DNA that contains required gene from source chromosome, extract required gene, insert required gene into vector/bacterial plasmid, insert plasmid into host cell and grow transformed cells to produce a GM organism.	production of medicines for human use e.g. insulin and growth hormone	Links with Life on Earth Unit.

Table 4.3 Modified by the National 5 Biology Support Notes (SQA, 2013f: p.10).

In the SQA document dealing with this subject the focus is on public concern about the technology of cloning. As mentioned in the literature review, science curricula tend to address possible problems related to the anxiety induced by the new biotechnologies by informing the students about the medical purposes and the societal benefits. This is also confirmed by the five mandatory statements that illustrate the mandatory area called “Human Impact on the environment” of the unit *Life on Earth*. These are: 1) Increasing human population requires an increased food yield. 2) Fertilisers can leach into fresh water, increasing algal blooms, which leads to a reduction in oxygen levels. 3) Pesticides sprayed onto crops can accumulate in the bodies of organisms over time. As they are passed along food chains, toxicity increases and can reach lethal levels. 4) Indicator species are species that by their presence or absence indicate environmental quality/levels of pollution. 5) Biological control and GM crops may be alternatives to the use of fertilisers and pesticides.

Natural selection, adaptation, competition, cloning, applications in agriculture and medicines are key words in the vision of evolutionary biology emerging from the mandatory areas of the CfE biology progression framework. Evolution, human evolution, phylogenetic trees, trees of life, cladograms, tree diagram, tree thinking are all words and concepts that are not explicitly presented although they are implicit in many of the abovementioned mandatory key areas from N3 to N5 qualification. Biology teachers can make those links with evolutionary biology, but this is left to his or her discretion.

The open structure of the texts, the flexibility of the CfE and the active and creative role invoked for teachers allow the teachers to interpret the biology specifications in that direction. In fact, “the context for Mandatory Course key areas are open to personalisation and choice” (SQA, 2013f: p.7). However, a peculiarity of the CfE should be highlighted. The SCN 3-20a outcome and experience states: “I have collaborated with others to find and present information on how scientists from Scotland and beyond have contributed to innovative research and development” (Scottish Government, 2009b: p.277). The N5 Biology Course Support Notes suggest, as a non-mandatory learning activity, that students “research biologists e.g. Watson and Crick, Rosalind Franklin, Maurice Wilkins, Chargaff” (p.9). It is peculiar that the CfE biology progression specification, beyond missing the words evolution and phylogenies, does not even mention the name of Charles Darwin, the father of the intellectual revolution that went far beyond the confines of biology.

4.3 The link between Evolutionary Biology and GCE in the textbooks

This section reports the findings of the analysis of Scottish Students’ Biology textbooks, and is limited to stages up to National 5 for the reason I have mentioned previously. The textbooks analysed are:

1) Souter, N., Chambers, P. and Jeffrey, S. (2010) *Science for Excellence, Level 3: Biological Science*. Hodder Gibson, Paisley.

2) Souter, N. (2015) *Biology, National 4*. SQA Endorsed, Hodder Gibson, Glasgow.

3) Cook, M. and Thornhill, F. (2015) *Curriculum for Excellence N4 Biology, BrightRED Study Guide*. BrightRED Publishing, Edinburgh.

4) Cook, M. and Thornhill, F. (2013) *Curriculum for Excellence N5 Biology, BrightRED Study Guide*. BrightRED Publishing, Edinburgh

5) Torrance, J. (2013) *Biology with answers, National 5*. SQA Endorsed, Hodder Gibson, Glasgow.

6) Bocian, C., Forrest, D. and Smith, B (2013) *Biology, Student Book, National 5*. Leckie & Leckie Ltd, Glasgow.

The analysis explored the following research question: In these textbooks, *what are the omissions and constraints that might result in distorted communication and preclude possible interpretations of the link between EB and GCE*?

In the first part of this section, I highlight omissions in the textbooks in treating EB topics. In the second part, I explore the kind of EB that emerges from the textbooks in relation to GCE by highlighting what aspects of EB are prioritised and what aspects are undervalued or ignored.

4.3.1 The omissions in treating evolutionary biology topics

In all the analysed books, a number of EB themes are omitted or poorly represented. These include phylogenesis, the common descent theory, inter and intra species DNA comparison, and the relationship between biodiversity and evolution.

A clear feature of the biology textbooks is the absence of phylogenetic trees and cladograms. In the five books analysed there is only one phylogenetic diagram. That is a simplified version of Darwin's finches phylogenetic tree (Bocian et al., 2013: p.313). In all the other textbooks, there is not a single tree diagram or cladogram, although in a biology course there are plenty of opportunities for introducing students to tree thinking and to phylogenesis. For instance, in all the analysed textbooks, the first chapter is dedicated to cell theory. Typically, all books show pictures of animal, plant and bacterial cells, explaining that plant cells possess cell walls unlike animal cells and that bacterial cells, unlike plant and animal cells, do not possess nuclei and other membrane-bound organelle. A very simple phylogenetic tree, like that in figure 4.1, would introduce students to tree thinking in the first play.

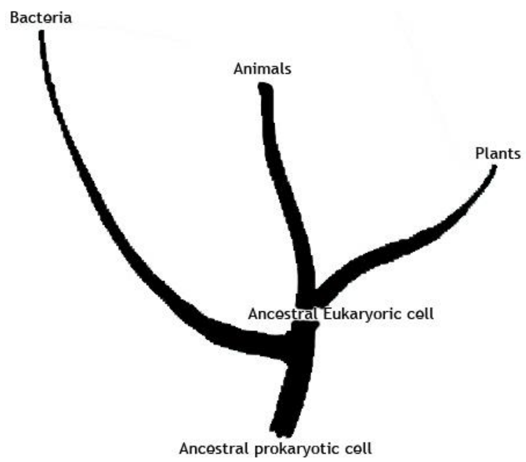

Figure 4.1 Simplified Phylogenetic tree of Prokaryotes and Eukaryotes

The simplified phylogenetic tree would explain the reason why all the tens of thousands of bacterial species do not contain nuclei, while all the animal and plant cells do. That is because the animals and the plants, but not the bacteria, descend from the same ancestral eukaryotic cell that possessed nuclei and that approximately 2 billion years ago originated in a modified bacteria-like cell.

The same simple phylogenetic tree would also be useful in the following chapters of the textbooks, which deal with genetic code consisting of DNA carrying the information for making proteins. In fact, the tree would briefly explain why all living beings have the same genetic code. That is because all living beings descend from the same ancestral prokaryotic cell which used DNA as its genetic code. These are only two possible examples to the benefit of non-biologist readers. The use of phylogenetic trees to introduce students to tree thinking can be extended to virtually any biology topic.

In addition to the complete lack of phylogenetic diagrams, another aspect that is very poorly represented is the Common Descent theory. As I mentioned in the literature review chapter, the common descent theory is one aspect of Darwin's theory that was more enthusiastically accepted by scientists who recognised and appreciated the explanatory power of its classification system. However, in all the textbooks analysed there is very little room for the theory. As a consequence, the concept that all the living species are related is omitted by the textbooks. Only the Cook and Thornhill's study guides implicitly mention it, by supporting the photos of a *zorse* (hybrid from zebra and horse) and a *liger* (hybrid from lion and tiger) with the following text: "Sometimes individuals from closely related species can mate and produce hybrid offspring" (2015: p.54).

In the five books analysed, the common descent theory is mentioned on only two other occasions. One is in the 2015 Souter's textbook. Souter refers to the common descent theory in his illustration of variability in birds on the beach: "All bird species possess the same ancient ancestor. They are believed to have evolved from small carnivorous dinosaurs that lived more than 150 million years ago" (p.127). The second is, again, in Cook and Thornhill's N4 textbook (2013) where they illustrate the speciation that resulted in the Galapagos finches and state that "this single species of finch [the ancestral species arrived from the mainland of South America] has evolved into a range of different species which utilise different food sources" (p.112).

It is also interesting to note that our species is not represented in any phylogenetic trees and there is no mention of the fact that there is a common ancestor for all living beings on our planet. The comparison of DNA in different species as a proof of the common descent theory is not mentioned at all. Based on the same principle that allows this method to be used to resolve paternity issues, the studies of sequences in the molecules of DNA could be used to demonstrate, for instance, that humans are more closely related to chimpanzees than to dogs, more to dogs than to banana plants and more to banana plants than to bacteria (Dawkins, 2004). In addition, the method could be used to show that chimpanzees are more closely related to humans than to any other monkey, raising the issue of their use in experimentation and zoos.

Beyond interspecific DNA comparison, intraspecific genetic comparison is also poorly represented. This is an important aspect that would provide an opportunity to raise in the classroom the thorny issue of human classification. There is no mention of the substantial genetic equality of humanity in any of the analysed textbook. One example that illustrates this point well is in Torrance (2013). In the chapter “Variation and inheritance”, the topic of “Continuous variation” is treated using the example of human height. The topic is an excellent opportunity for textbooks to show the analogy between skin colour and human height and to maintain that the division of our species based on skin colour is as much a scientific nonsense as would be the division of races based on human height.

In the EB topics treated by the textbooks our species is almost totally disregarded. The textbooks omit to explain that the human intraspecific biological variation is limited to a few characters and that our species is closely related to others. References to our species in the chapter “Adaptation, natural selection and evolution” are only related to disease and suffering. For instance, Torrance (2013), in the second page of the chapter (p.177), shows the image of a young female victim of the Chernobyl disaster with a big white patch applied to her upper chest. In the same chapter of the same book, another photo shows a child affected by cystic fibrosis lying down and being treated by a healthcare professional.

Finally, a further feature of the analysed textbooks is a lack of clarity with regard to the origin of biodiversity. Biodiversity is typically treated in a chapter that precedes another chapter on adaptation. None of the analysed textbooks explicitly connect the origin of biodiversity with the Darwinian theory of multiplication of species, that is speciation and its explanatory power with respect to the enormous diversity of life.

4.3.2 The narration of Evolutionary Biology

The theory of evolution is presented as a solid scientific theory “accepted by scientists since it is supported by lots of evidence […] with no real controversy in science [but] disputed in unscientific ways" (Souter, 2015: p.125). The textbook narrative of evolution is "adaptation for survival", rather than "common ancestors". In fact, all the textbooks analysed show simplifications, lexical sequences and redundancies describing "appropriate adaptations" enabling species "to exploit a particular niche" (Torrance, 2013: P.180). The following excerpts are cases in point.

"In order for plants and animals to survive in particular environments, they must be adapted to the conditions found there (Cook and Thornhill, 2015, p.86)".

"Adaptations can be structural, physiological and behavioural and help organisms to survive and reproduce in their environment (Souter, 2015: p.125).

Redundancies consist of providing students with extreme examples of adaptation and examples of living beings unable to survive in different environments from those in which they normally live. For instance, Souter gives the extreme example of how weird it would be to see "a cactus growing in Edinburgh's Princes Street garden", "camel herds in the Cairngorms or a polar bear in the Minch" and "a fish swimming outside your local shops!" (2015: p.125). Torrance highlights that "a normal land plant (such as an oak tree) would be unable to survive in the desert" (2013: p.180). Similarly, Cook and Thornhill emphasise that "a polar bear is adapted to live in the Artic and could not survive in the desert" (2015, p.86).

The simplification consists firstly in providing examples that are extreme instances of adaptation. Nature offers also good examples of great plasticity in adaptability. For instance, one of the most widely known and studied mammals in the world, the house mouse, *Mus domesticus*, presents biological traits that contribute to its amazing adaptability that have enabled this species to colonise habitats as different as the Antarctic tundra and tropical atolls (Berry, 1981). A further case in point is the example of another group of living beings widely known and studied, bacteria. Thanks to high population numbers, their great genomic plasticity and their capacity to exchange genetic information between very different species, bacteria provide an excellent example of adaptability that allows them to be the most extended form of life on our planet ever (Rodríguez-Rojas et al., 2013).

In addition, by providing extreme examples, the fact that an adaptation which allows an individual to survive in one environment does not necessarily make that individual unable to survive elsewhere, is not mentioned. Moreover, there are studies that show that adaptive plasticity can itself be adaptive and thereby beneficial and maintained by selection (Gotthard and Nylin, 1995).

A further simplification found in the textbooks is the description of species as real actors struggling for survival. For instance, Cook and Thornhill (2015, p.86) defines adaptation as “an evolutionary process, allowing a species to be better able to live in its habitat”. However, the target of natural selection is each individual living being, not each species. In fact, it is the individual that either possesses or not the inherited characteristic enabling it to survive and reproduce. It is the individual living being that struggles to survive, reproduces, lives or dies. Therefore, a species is only the result of the evolutionary process selecting a myriad of individuals. By talking about species as real entities subject to natural selection, the risk is to foster in students a typological way of thinking.

The narration of EB in the textbooks is thereby not about nature as constituted by different living beings sharing common ancestors, DNA, biochemistry, structures, physiology, behaviour and the struggle to survive. Rather, it is the narration of different species with structural, physiological and behavioural adaptations that make it possible for them to survive in particular environments, but not in others.

The focus on diversity in adaptation, the omission of even a basic natural history and the disregard of genetic equality are not the only features emerging from this narrative. A further feature is the fact that evolutionary processes are something that is beneficial or harmful to human beings. In Torrance's textbook, for instance, in the very first page of the chapter entitled "Adaptation, natural selection and evolution" (2013: p.76), before any definitions of natural selection and evolution, the author maintains that "mutagenic agents can be used by geneticists to try to create new mutant varieties of organism that are useful to humans" (2013: p.176) and provides the examples of a strain of a barley that is resistant to heavy rain and a rice plant with improved hardiness to cold.

The same author (Torrance, 2013), when listing mutagenic agents, informs us that X-rays damage DNA directly by breaking it up. However, he maintains that "occasional exposure of an individual's cells to X-rays for medical purposes is not harmful" (2013: p.177). Such a statement seems to serve no purpose other than to educate young citizens to obedience. In the only chapter explicitly dedicated to EB (thirteen pages, including the end-of-chapter questions), this statement not only does not contribute any useful information for the understanding of EB, but is also misleading, as it does not accurately inform about the risks of medical X-rays. In fact, there is consensus that the risk of radiation-induced cancer at low doses of radiation rises as a simple function of dose, without threshold, for most types of cancer (Wall et al., 2006). In other words, doctors agree that the risk from low doses is lower than for high doses. Nevertheless, there is risk in any case. In addition, there are radiologists who believe that low doses of radiation can be even more damaging than this hypothesis predicts (Wall et al., 2006).

By classifying the mutation in neutral, disadvantageous and advantageous, Torrance defines the latter as those that produce an "organism that is **better** than the original" (2013: p.178, bold in the text). This is clearly misleading and doesn't help the understanding of EB, because the evolutionary processes consist of the survival and reproduction of those organisms that are adapted to one certain environment instead of others. Therefore, a living being is not better or worse, but adapted or not to a given environment. In addition, the author supports the definition of advantageous mutation, giving the example of wheat, tomatoes and strawberries that have seeds and fruits with increased size. Such phenotypes are not an advantage for the individual plants. Rather, the advantage is economic for the system of wheat, tomato and strawberry production and trading. In other word, the economic advantage is only relevant for humanity and, thereby, the example does not contribute to the teaching and learning of evolution.

A further example is provided by Bocian et al. (2013). In their narration, they mention *Agent Orange*, a powerful herbicide, which turned out to be a powerful mutagenic agent and was used by the US army during the Vietnam War, causing a host of very serious medical problems to the civil population and the militaries. They also highlight the economic importance of polyploidy plants because they are larger in size and grow more vigorously, and their medical issue for cystic fibrosis, one of the most commonly inherited diseases which affects more than 9,000 people in the country.

Torrance (2013) again, by raising the issue of antibiotics and their over-prescription, sums up in a very worthwhile and concise way the key idea of natural selection. The explicit purpose consists in making the students aware that the improper use of antibiotics can result in a rapid selection in favour of bacteria that are resistant to antibiotics. However, the example used to explain EB is once again one that draws on the benefit or harm to human beings. In another example described below, the resistance of insects to built-in insecticides in GM plants, the narration does not include the struggle of insects and plants for survival. Rather, the human struggle against nature appears to be central.

The mini lesson on insect-resistant GM plants is in the form of a case study. First, it is described how a transgenic variety of a cotton plant is resistant to the pink bollworm, the insect *Pectinophora gossypiella*, thanks to the insertion of a bacterial gene that codifies for the production of an insecticide. However, the author then highlights that a strain of pink bollworm resistant to the insecticide made by the transgenic cotton plant has already been discovered. The case study continues by mentioning a transgenic variety of corn made resistant to the European corn borer, the moth *Ostrinia nubilalis*, through another bacterial gene that enables the plant to produce an insecticide. Torrance maintains that, in the attempt to “delay the natural emergence of resistant corn borers” (p.185), farmers must, by law, plant non-transgenic maize in the nearby fields “to slow down the evolution of the type resistant” (p.185).

The case study, rather than highlighting the extraordinary struggle for life of the *Pectinophora gossypiella* and the *Ostrinia nubilalis*, gives an example of how, thanks to the collaborative work of farmers, policy makers, scientists and traders in cotton and maize, humanity defies nature. This narration of evolution, besides being focused exclusively on humanity, also risks being misleading. In fact, Torrance continues by maintaining that “however, it is only a matter of time until a strain of corn borer resistant to the built-in insecticide appears” (p.185). In the statement, there is the idea that the European corn borer would necessarily evolve towards the resistant type and a teleological assumption seems to be implicit. There is also the idea that humanity is entitled to destroy the species that damage its activities. In addition, Torrance’s statement might elicit in students the Lamarck's theory of inheritance of acquired characters. In fact, Yip maintains that the relationship between genetic variation and evolution is a difficult concept for secondary school students and that “a common misconception is that genetic variation makes the individuals better adapted to the environment” (Yip, 1998: p.474).

Cook and Thornhill (2013), like Torrance, illustrate issues relating to the over-prescription of antibiotics and to insect resistance to built-in insecticides in GM plants. The title of the section is suggestive: “Examples of adaptation which cause problems” (p.111). Clearly, the amazing adaptability of the Staphylococcus aureus and that of the European corn borer are used by the authors to highlight the problems that the former may generate in hospitals and the latter to the trade system. In other words, the focus is not evolution, but the evolution-related issues that may damage human economy or human health. In addition, Cook and Thornhill's text may result in misinterpretation by the readers. In fact, they end the section by maintaining that "This [growing GM crops alongside non-GM varieties] reduces the overall damage caused by the moths, while not increasing the chance that natural selection will produce populations of moths that are all resistant to the plant toxins" (2013: p.111).

Maintaining that "natural selection will produce populations of moths" rather than "natural selection will select population of moths already present in nature" can create ambiguity that can result in reinforcement of the misconception that acquired characters are inherited. As I have already mentioned, Lamarckian misconceptions are one of the most common problems encountered in teaching EB. A more Darwinian interpretation of the same issue is made by another text (Bocian et al., 2013). While illustrating the same topic Bocian et al. maintain that the effectiveness of the GM crops described has decreased since the technique has been in use because "some insects had a natural resistance to the toxin produced by the plant. They survived and passed on the advantageous allele to the offspring" (p.316).

The chapter in the Cook and Thornhill textbook that is dedicated to EB is also not attentive to the wide range of research that shows that the survival of the fittest is a poor descriptor of evolution. In fact, the second and last section of the chapter starts with "Natural selection is sometimes referred to as '**the survival of the fittest**'" (2013: p.112, bold in the text). In addition, the same textbook (p.89) describes adaptation as a characteristic that is usually inherited. However, since if it is not inherited it is an acclimatisation, rather than an adaptation, the statement can promote a vernacular misconception.

In conclusion, my analysis shows that the textbooks prioritise some aspects of EB and undermine and ignore others. In addition, this analysis highlights simplifications, lexical sequences, narratives and redundancies that make evolution appear as the adaptation for survival, rather than the history of common ancestors. Therefore, the sturgeon fish, rather than being a sort of distant cousin, is the “source of the delicacy, caviar” (Cook and Thornhill, 2015: p.89). In fact, the narration of EB in the textbooks is characterised by a disregard of tree thinking, a lack of clarity about the origin of biodiversity, and by the omission of phylogenetic trees, the common descent theory, human evolution, if not as negative example, human classification and the genetic equality of the human population.

Chapter five: Findings of the phenomenographic analysis

5.1 Chapter overview

In this chapter, I illustrate the findings of the analysis of the transcripts of the interviews with the biology teachers. Section 5.2 explores the participants' conceptions of educating for GC in the biology classroom. Sections 5.3 analyses the ways they perceive the interplay between EB and GCE. Each section integrates the findings of the qualitative preparatory content-thematic analysis with the phenomenographic study. This chapter devotes a great deal of attention to the participants' words, providing the reader with an illustrative sample of raw data. Participants' quotations are followed by the identification code I attributed to the teachers, such that T1 is for teacher 1, T2 for teacher 2 and so on. Sections 5.4 illustrates the reported constrains perceived in the interplay between Evolutionary Biology and Global Citizenship Education. I conclude the chapter with section 5.5, by summarising the findings in an outcomes space, that is the description of the structural relations among the different conceptions in the collective mind of the participants in this empirical study.

5.2 Findings related to the research question: *How do educators conceive of global citizenship education in their role as secondary school biology teachers?*

Iterative readings and the analysis of the interview transcripts revealed differences in the understandings of the biology educators concerning the nature of the interrelation between SB and GCE. In this section, I first provide the reader with some general information about how the participants viewed the idea of educating for GC through SB. In doing this, I also mention the stated pedagogical approaches, list the main themes considered useful by the participants and outline the findings of the phenomenographic analysis in relation to the research question "How do educators conceive of global citizenship education in their role as secondary school biology teachers?". The findings are then detailed from Section 5.2.1 to Section 5.2.4. I conclude with a summary of the findings in Section 5.2.5.

Content and thematic review

Most of the participants, when asked to reflect on the relationship between biology and citizenship, acknowledged a significant role for science education in educating for GC. They recognised biology as a natural vehicle for dealing with GC issues. The following quotation is representative of the majority of the participants.

> *Well, biology because it is so broad, it encompasses so much to do with citizenship because you are studying all living things and living interactions, there inevitably is an impact globally from that.* (T12)

From the transcripts, the participants' idea that biology is a school subject that is congruous with the purpose to educate students for GC emerges clearly: biology is the study of life, it is everywhere and it is often object of media interest. This makes the link with everyday life of citizens obvious. In participants' account, news reports on scientific research can be a source of scientific knowledge that students can integrate and compare with school science.

> *R: What opportunities does biology provide for students to explore citizenship issues?*
>
> *A lot, I think biology is actually of all the sciences it is the best dealing with that* […] *with biology there is a certain way to talk about everyday issues in the newspaper through biology. And at the same time as me telling them about the papers or the news, it is something that they can use in their studies. So I am finding biology a very good vehicle to talk about everything from pollution or how much meat we eat and how healthy it is, to the proposed expedition to Mars for instance.* (T17)

In the attempt to explain how SB can be linked to GC, most of the participants discussed several topics ranging from health science to sustainable development (Table 5.1). The following excerpt is a case in point.

> *I have talked about sustainable education, talking about food production, also fuels and alternative fuel production. But there is* [sic] *also ethics and medical advances and science, so it could be DNA profiling and the ramifications of that, new anti-viral immunisation programmes or even debates to do with DNA, debates to do with distribution of drugs and healthcare.* (T13)

In relation to the pedagogical approaches to be adopted in order to integrate biology with citizenship (table 5.1), most of the teachers stated they used active learning techniques with the declared aim to make the students develop their own ideas, rather than providing them with answers.

> *We have debates, as an example, we had a cloning debate, whether or not it's been ethical or not* […] *also use creative learning, active learning, sort of producing posters that have pros and cons of a subject. We use speech bubbles so, for example, a speech bubble represents different people* […] *We use 'think pair share' where they pair up with a partner and they share the views with the partner and then also that pair can then share the views with another pair and what they do they put that information to the class. We also use Powerpoint; pupils can put their views or beliefs on to a Powerpoint and present it to the rest of the class. We also use news stories from the internet, we go onto BBC News, Sky News, to find interesting stories and read through them.* (T15)

With the exception of two teachers (i.e. T8 and T9), all the others interviewed seemed to consider that it was their responsibility to educate students for responsible GC. These two teachers seemed to show a sceptical view on the meaning of GC itself. Although they did not seem to argue against educating for citizenship in the context of the science instruction, they seemed to restrict the discourse of CE to issues of belonging to local communities.

> *Global citizenship? I don't actually know what that means.* […] *Global citizens? Aye. See we use words a lot but sometimes when you have to explain them it's quite hard to do* (T8)
>
> *Does citizenship not mean belonging to a country? A citizen of a country?* (T9)

All the participants, including the two sceptical teachers, mentioned opportunities and/or raised issues of CE in the biology classrooms. Indeed, from the interviews, a very wide range of themes relating SB to GCE emerged: from health science to the science-religion debate; from the educational aims to promote empathy, to the different pedagogical approaches adopted; from biotechnologies to the uncertainty of the scientific knowledge (Table 5.1). In summary, the numerous themes addressed by the interviewees in their attempt to link SB with GCE are themes and issues related to the role of the teachers; pedagogical issues related to the ethical and cognitive development of students; specific issues related to the educational aim of promoting the integration of the students in the world and society; biological topics; and issues related to the implementation of the national curriculum and the biology syllabi.

Key citizenship words	Biology areas of interest for linking SB to GCE		Pedagogical tools
• responsibility • social justice • role in the world • impact on the planet • resources • sustainability • bioethics • biosphere • environment • stewardship of the planet • biodiversity • conservation • food • water • working together • enterprise • contributing workplace	• species conservation • animal survival • habitat conservation • plants • environmental biology • pollution • planet health • pesticides and insecticides • fertiliser application • farming methods • deforestation • health science • well-being of the body • new medicines • vaccine • food security • diet • nutrition • genetic modified food	• biological homogeneity of humans • kinship among human • kinship between humans and other species • race • mutations • evolution • antibiotic resistance • human evolution • natural history • tree of life • common descent theory • biological unity • genetic engineering • gene manipulation • gene banks • seed banks • renewable energy	• relating biology to society • promoting science as a way of knowing • criticising anthropocentric views • debates • group works • discussing news • discussing science application • relating to socioscientific issues • *CfE*

	• healthy eating • body in action • transplanting organs • stem cell research • global warming • climate change • advances in genetics • human genetics	• resource sustainability • global food supply • biosphere • biodiversity • biotechnology • discontinuous and continuous variations • bioethics	

Table 5.1 Summary table listing the main themes linking SB to GCE emerged from the interviews

Phenomenographic analysis

From the phenomenographic analysis of the transcripts, three different ways of conceiving the education for GC through school biology emerge. In the attempt to represent their meaning, I labelled these conceptions, which represent the main categories of description of the analysis, in the following way:

Educator identity (A): *Global Justice*;

Educator identity (B): *Environment Sustainability*;

Educator identity (C): *Individual Development*.

Each conception constitutes a spectrum of attributes, that are ideas and features emerging from the transcripts. In the following sections, I illustrate the categories in turn, initially describing the category in a general way and then focusing on the attributes constituting each category, supporting the attributes of each category with relevant quotations.

5.2.1 Citizenship educator identity *(A): Global Justice*

This conception includes statements where the participants link GCE and SB using arguments that pertain to a global demand of social justice.

It's [GC] *a citizenship justice for all.* (T10)

As I mentioned in the methodology chapter, in phenomenography a conception is the main unitary category of description that emerges in the analysis when a number of excerpts of the transcripts can be related to each other. When more excerpts express the same or similar thoughts they are clouded in the same attribute. Table 5.2 lists the attributes, identified in my study, constituting this conception.

Conception	Attributes	Participants
Citizenship educator identity (A): Global Justice	Acknowledging that biology is related to inequalities	T1, T2, T13, T19, T20
	Acknowledging the role of biology in systems of profit	T1, T10 T20
	Acknowledging our responsibility for what is happening in other countries with respect to the exploitation of biological resources	T1, T2, T10, T12, T13, T16, T20
	Acknowledging commonalities among people and promoting empathy	T1, T12, T16, T17

Table 5.2. Summary of the attributes constituting the conception *Global Justice* and lists the participants from whose quotations the attributes and the conception emerged.

Acknowledging that biology is related to inequalities

I have labelled an attribute with the sentence "acknowledging that biology is related to inequalities" because teacher 1, for instance, linked issues of inequalities to health science.

> *There is definitely inequality between the first world and developing world, you know, in sort of health science* (T1)

Health science in the biology classroom can be easily related to human anatomy, human physiology, nutrition, individual well-being, biochemistry, individual responsibility, drugs and alcohol abuse, among other topics and issues. However, when teacher 1 was asked to discuss its role as a citizenship educator in his function as a biology teacher, he first mentioned the inequalities between the richest and the poorest areas of the world, arguing for the educational aim of making students aware that there are in the world biology-related issues of injustice.

Teacher 20, who raised the issues of unequal access in the world to clean water and vaccinesis another example of this way of thinking.

> *Other countries can't always afford all the vaccines* […] *Then just the sustainability and things like access to clean water and things like that.* (T20)

The topic of vaccines can be clearly related to other citizenship issues. In fact, one of the stated aim of the National 3 Biology Course is "Develop an understanding of biology's role in scientific issues and relevant applications of biology in society and the environment" (SQA, 2013a: p.4). Within this course, the specification demands biology teachers to inform learners about the "Body defences against disease and role of vaccines" (SQA, 2013a: p.5). Therefore, a biology teacher may mention the social function of vaccine by highlighting that their effectiveness in preventing infectious diseases in societies depends on the high rates of acceptance and coverage. He or she could plan a lesson based on news reporting cases of parents refusing to vaccinate their children because of a supposed association between vaccine and autism and scientific evidences against such a causal association (DeStefano, 2007). However, the participant interviewed chose to highlight the fact that the poorest countries in the world cannot afford national immunization programmes for economic reasons. Similarly, by mentioning at the same time the unequal access to clean water, she linked vaccine to a political discourse rather than connecting it to epidemiology or to the citizens' scientific literacy.

I clustered in the same attribute the following quotation because the interviewee linked the Scottish biology curricula to social issues of another continent, where inequalities resulted in social agitation.

> *There were the food riots in 2012 in Venezuela and things like that so that was really good when we were talking about food security, which is part of the course for National Four and National Five.* (T2)

I found also the following quotation closely related to the two abovementioned. In fact, teacher 13 made a link among her concern for the problem of unequal distribution of resources in the world, the possible role of biology, through genetic engineering, in solving the problem and the bioethical issues related to the biotechnology of genetically modified food.

> *We do debates on food, on distribution, world trade and the idea that some people have plenty and people have too little and how you would solve the problems to do with that and how there are biological interventions through genetically modified food and the ethics surrounding that.* (T13)

A different connection between biology and injustice was suggested by participant 19. She mentioned a global event like the Olympic Games to raise issues of biological citizenship and the need to be aware that ethics is modelled by politics and conventions. Although she did not focus on differential access to resources, I clustered her quotation in the same attribute because her focus was on a form of injustice. The injustice due not to poverty, but resulting from discrimination based on the citizens' biocultural identities. As for her colleagues, her concern was about the political dimension of the link between SB and GCE.

> *I think there are very controversial topics, I am just thinking recently with the Olympic Games and their ban on homosexuality* […] *so being aware of how politics in different counties and members of those countries can influence your view on evidence that is presented.* (T19)

Acknowledging the role of biology in the systems of profit

Another attribute linked to the conception "Social Justice" that emerged from the analysis of the transcripts was labelled 'acknowledging the role of biology in systems of profit' as it clusters the quotations that suggest that biology is interconnected with the injustices in the world. Therefore, in the participants' interpretation of including GCE in the teaching the topic such as vaccines for instance, the link is the call for the awareness that the benefits of science are not available to all the people in the world. Hence, if the participant's statements were reported in the classroom, teaching health science could become a means to uncover the system of injustice in which the biomedical sciences are involved.

> *R: The next thing I'd like to discuss is about themes, topic, so what themes within biology do you think might have particular links with global citizenship?*
>
> *I would say health science definitely, so how for example, vaccines you know, we've got a lot of first world drug companies, who are possibly charging too much for people who are suffering from AIDS or malaria.* (T1)

The same relationship between SB and GCE emerged from other participants who viewed Genetic Engineering as a possible link between the two variables of this study. Genetic Engineering is a mandatory course key area (SQA, 2013c: p.5). The suggested learning activities in the National 5 Biology Course Support Notes have clearly the purpose to show how genetic engineering of plants offers significant potential for seed, agrichemical, food processing and pharmaceutical industries (SQA, 2013f). However, the participants' statements highlighted that there is a system of exploitation associated with the production of genetically modified crops which affects the life of people living in the poorest countries of the world.

> *Then thinking about people in other countries, they need to buy new seeds every year from whatever companies have the GM crops.* (T20)
>
> *And also of course in terms of the Bioethics that we're actually engaged in terms of the new techniques such as the genetic modified crops and the genetic engineering, and then how that is going to impact on other countries and other people.* (T10)

Acknowledging our responsibility for what is happening in other countries with respect to the exploitation of biological resources.

The third attribute of this conception emerged from the statements of a group of participants that, when attempting to explain how SB is linked to GCE, argued for a sense of our responsibility, as inhabitants of the richest and most powerful countries of the world, for what is happening to people living in other countries of the world.

> *The role that we play as a country in terms of our position, in terms of the economy,* […] *the part that we play as a major power and in the decision-making, that we are making and how that influences the lifestyle and the life choices that are available in other countries because of that.* (T10)

The participants, when explaining what they meant by GCE as a biology teacher, claimed that we have responsibility and obligations to the people living in other parts of the world.

> *R: What does global citizenship education mean to you?*
>
> *It means taking some sort of individual responsibility for things that are happening in the world* […] *for example being interested in sustainable development* [and] *about moral obligations and about whether it is our responsibility to consider what is happening to other people.* (T20)
>
> *I feel we have a responsibility to think about our actions and what's the consequences of our actions. So, you know say we, I'm just trying to think, say a big corporate firm maybe located in the UK, however it will be, because it's international business, it will have an effect in other countries.* (T1)
>
> *Getting that idea across that you are not bound by your locality, that the world is your oyster. […] They start to understand that science is not restrictive that it includes the whole world and to try and get them to think about the possible impacts not just on here but all subsequent things.* (T16)

In a similar fashion, teacher 13 highlighted the importance of being aware of the impact of our actions in Scotland on a global level.

> *R: What is global citizenship and what does global citizenship mean to you?*

In terms of global citizenship, it is maybe realising what happens here in Scotland impacts all over the world, how things like sustainability will impact on food production, food security, ethical considerations to do with food, also in terms of medical advances in science and understanding how they can play a role in that and how that can impact on a global level not just within the UK or within Europe but a much wider field. (T13)

Similarly, teacher 2 and teacher 12 suggested that biology education should aim at promoting responsible social behaviours and make students aware of the consequences of their actions at a local as well as a global level.

I just think it is about letting the pupils make informed decisions about what is happening in the world and that they play a part in it. (T2)

Hopefully people from this school and other schools will rise up and actually have some kind of influence over what happens in the world so that is really important to get them to develop the skills of taking responsibility for their own actions and think about the impact for other actions as well. (T12)

Acknowledging commonalities among people and promoting empathy

The existence of the conception *Global Justice* is also supported by a fourth group of interconnected statements. I collected them under the attribute "acknowledging commonalities among people and promoting empathy".

You know we're all the same, we all suffer, you know at some point in our life from different ailments so I think that would be one thing that we could say connects all of us (T1)

This group of statements suggested that GCE consists in creating a sense of commonality and in promoting attitudes of empathy.

R: First of all, what does global citizenship mean to you?

Being aware of the impact of your actions and those around you on the entire world and the fact that everything has a consequence and to look out for other people globally (T12)

In this respect, biology was presented as a universal language useful for the global dissemination of ideas, human rights and bioethical dilemmas.

> *I think it* [GC] *is being able to communicate all across the world* […] *in terms of their rights and like global ethics, dilemmas and questions in biology.* (T16)
>
> *I would imagine global citizenship is a cultural understanding of things people have in common I presume. […] Looking after our environment, treating each other with respect things like that. […] working towards a certain aim and that is to have a peaceful equal world as much as possible* (T17)
>
> *R: What does global citizenship, education mean to you?*
>
> *I think it is being able to communicate all across the world […]it is getting that idea that that actually it is not just, not even just a city, but also not just – Scotland is going through the referendum so they are just thinking about Scotland very much – […] I think the idea of a being a global citizen. I link that very closely to human rights.* (T16)
>
> *We're just one community altogether, even though we live in different countries, different parts of the world, we're all one together. That's what global citizenship means to me, we're all one society.* (T1)

5.2.2 Citizenship educator identity (B): *Environment Sustainability*

Another way of weaving the picture of the role of the biology teachers as global citizenship educators emerged from the sections of the transcripts that linked ecological issues, environmental education and the Scottish biology curriculum. This category of description consisted substantially in the reported idea of developing, through biology education, students' ecological conscience.

> *To me global citizenship would mean the environmental. (T10)*

Table 5.3 lists the attributes of this conception.

.

Conception	Attributes	Participants
Citizenship educator identity (B):	Impact of human activities on environment and finiteness of resources	T5, T6, T20, T21
	Environment & biodiversity conservation	T4, T5, T9, T16, T18

Environment sustainability	Linking school biology with environmental and global economic issues	T10, T14, T16
	Responsibility in the stewardship of a shared planet	T6, T10, T14

Table 5.3 Summary of the attributes constituting the conception *Environment sustainability* and the participants from whose quotations the attributes and the conception emerged

Impact of human activities on the environment and finiteness of resources

Within this conception, a clear aspect of the link between GCE and SB consisted in arguing for the stated educational purpose of developing in students the awareness of the global impact of human activities on the environment.

> *I try to extend children's thinking to the fact that we have an impact on the greater world but the world has an impact on us as well. […] I think we make it very clear to the students that a lot of the issues in the world, a lot of the concerns, and a lot of the problems are of man's making because of not understanding, I suppose, global citizenship.* (T21)

When reporting the link between SB and GCE in this way, the call was not for the awareness for our responsibility for the socio-economic events happening in other parts of the world because of the unequal distribution of bio-related resources. Rather, the focus was on the awareness of our responsibility for the environmental changes happening also in other parts of the world. This way of talking about GCE in the biological classroom is related to the ecological conscience, rather than to the social or political awareness.

> *How the resources that they use and the approach that they take and the way that they live their lives has an impact upon on the rest of the world and how that impact may be felt around the world. (T6)*
>
> *For me it is when we are teaching things like human impact on the environment and things like that. It is considering what will happen in other countries and we will talk about climate change and things.* (T20)

Awareness, environment, sustainable use of resources and global impact were the key words of this way of reporting about GCE. In addition, within this account of CE, citizenship cannot be local. In fact, the environment is global in its nature. Therefore, participants within this framework highlighted that an unsustainable use of the resources in an area of the world has an impact on other areas, because we are all part of something bigger, greater, that is the planet.

> *I think it's about an awareness of just everything in the environment and the world as a whole and how you can impact it. What you can do for it and what you can do against it. How you live your lives, how it affects outside just your own wee bubble, global citizenship, making sure you know you're part of something bigger and greater. (T5)*

Within this framework, a stated educational purpose emerging from the interviews was the need to make clear with students that the human activities are jeopardising the resources of the planet.

> *Teaching pupils that there are different ways of life, there are finite resources available. So, understanding that different people live in different ways, have different resources available to them and understand how that can then impact on their life and what they do, basically.* (T6)

Environment & biodiversity conservation

With the analysis of the transcripts I found a second group of statements related to the attribute above (Impact of human activities on the environment and finiteness of resources) that however implied a slightly different meaning. I clustered these statements in a second attribute of the same conception. The thought at the core of this attribute is that people's actions on the environment can have a domino effect on the present and future ecosystems of the planet. Therefore, biology teachers in their function of citizenship educators stated to promote, in their classrooms, resource sustainability and the conservation of the environment and its biodiversity, starting from the environment in which students live.

We get them to sample different types of animals and plants that are in the local environment and we teach them about the importance of conserving them. (T5)

When discussing biodiversity and conservation with students, even if these topics are not directly linked to global citizenship, it should provide students with an idea of diversity because even though we may be different, we are still part of the same world. (T18)

R: As biology teachers working in Scotland, how do you view your role as global citizen educators?

So, is that not we're supposed to teach them about the environment and their role in the environment and looking after the environment and all of that sort of thing? So, that's how biology would be related to that. (T9)

R: what is your interpretation of global citizenship education?

How to maintain the environment that you live in; how you contribute to that; how you can maintain it and conserve it for generations that come after you so learning about all of the different aspects of the environment and not just in Scotland and in the world as a whole. (T4)

Human activities, by depleting resources and affecting the runoff of pollutants and nutrients, may result in changes to species composition and in alterations and destruction of natural habitats. Therefore, during the biology lessons, the argument against habitat destruction was central to this way of speaking.

Thinking about adaptations, natural selection we always use the Galapagos Islands and then we talk about should we actually preserve them. Things like in Brazil I know it has stopped at the minute but cutting down of the rain forests and habitat destruction. (T16)

Linking school biology with environmental and global economic issues

A third related attribute of this category of description clusters all the statements that link SB with both environmental and economic issues. Within this way of claiming the need to educate for sustainability, topics of the biology syllabus were considered opportunities for relating global environment and human economic activities, such as the industry and food production.

For example, you look at volcanoes in our first and second year units and we talked about the ring of fire in the Philippines and a lot of the pupils could not understand why anyone would live there if there was *a threat of volcanoes. But then actually talking about the soil and how that is really good for farmers to grow and if you are importing your food and talking about food miles. So, I think it is getting that idea that that actually it is not just, not even just a city, but also not just Scotland* (T16)

Participants reported that, in their role of global citizenship educators, biology teachers should make the students aware of the interconnections among biology, biotechnologies, school biology, environment and human economic activities.

The global citizenship for me would be trying to again raise an awareness within our students of the role that biology has to play, both from the environmental standpoint and from an industrial standpoint, how we are contributing towards other initiatives such as, as I say, genetically the modified foods. (T10)

The reported key idea was the following: biology teachers should make the students aware that they are part of a global economy and complex natural systems where different human populations are differently interrelated with other components.

We are much more of a wider global economy we have to make sure that children have a better understanding of the world as a whole and […] how other people live their lives and how they could part of that potential in the future […] and how our lives are dictated by many of those things [interdependence with fauna and flora] (T14)

Responsibility in the stewardship of a shared planet

Clearly connected to the previous, a further group of statements had as the common denominator the idea that we share the global environment with other people in the world and altogether we must oversee the stewardship of the planet.

The ownership of our planet, our responsibility to each other and to our surroundings […] In the biology perspective I think we are addressing much more of this type of issue now, because we have the ecology aspect in terms of the pollution, the rain forest, the climate changes, the responsibility that we have in terms of these aspects of stewardship of the planet. (T10)

Resource sustainability, understanding different cultures and being able to bring a sense of shared ownership of the world into the way that they live their lives, basically. (T6)

I think we should be ensuring that the children understand that they have a responsibility for the world as a whole. And trying to ensure that young people take care of the world that they have and look after it better than we have in the past. (T14)

5.2.3 Citizenship educator identity (C): *Individual Development*

A third way of conceiving GCE through SB that I identified while analysing the transcripts of the interviews was labelled *Individual Development* because its overall meaning is consistent with the educators' stated concern with the democratic, cognitive and ethical development of the students. Therefore, rather than 'changing the world' or 'saving the environment', educators argued for educating students to change themselves, by promoting healthy lifestyles and responsible behaviour towards other living beings.

We do with health education, they're looking after themselves with regard to the biosphere, the decline of the plant world, conservation of the plant world […] planting the plants and bringing them on and letting them grow and looking after them and all that sort of thing and trying to build in the responsibility element that they've got if they take on the job of looking after a living thing, then that's their job, it's their responsibility that they have and they have to do it. (T3)

Therefore, the emphasis here is on skill-building and taking responsibility at a local level. From this perspective, the biological knowledge itself appears sometimes of secondary importance in the educational process of educating for citizenship. For instance, teacher 21 openly asserted his commitment was to connect pupils with the real world and to help immature adolescents to leave the childish world in which they were still living.

Sometimes some of the topics that we have been teaching with the lower classes, they relate some of the facts that you are telling them to cartoons on the television, rather than to real life. (T21)

Table 5.4 reports the attributes and the participants associated to this conception.

Conception	Attributes	Participants

Citizenship educator identity (C): Individual Development	Work and responsibility in the community	T3, T5, T8, T11, T14, T15
	Democratic skills and impartialness of the teacher	T4, T5, T7, T19
	Understanding socioscientific issues	T2, T7, T11, T16, T17, T19
	Multiculturalism	T7, T18, T19, T21

Table 5.4 Summary of the attributes constituting the conception *Individual Development* and lists the participants from whose quotations the attributes and the conception emerged

Work and responsibility in the community

A first attribute emerged because the statements of a number participants were ascribable to the declared purpose to develop the skills enabling students to be integrated in their own community.

> *Taking part in the community and acquiring the skills to live and work in the outside world [and] to be socially sound.* (T15)

As a consequence, the concern of some participants was, in their words, to build and refine the students' employability skills, preparing them for their future job.

> *Also, aspects of enterprise, looking at the careers that are included in what you teach in biology.* […] *the aspects of ecology and also aspects of enterprise, looking at the careers that are included in what you teach in biology. Particularly the things like genetic engineering* (T14)

In other words, from this narration of the link between SB and GCE, the participation of the citizens in their society primarily starts with their integration in their local community through acquiring a professional role in a workplace. Therefore, this conception de-emphasises the global in favour of the local in GCE.

> *I think that's where our job as teachers lies, we have to build in the skills the attitudes, the responsibilities to allow them to then leave school and take that forward into the workplace.* (T11)
>
> *Well citizenship means, you know, what they're like in their community. I don't know! Citizenship is like with young enterprise they have to kind of like build their own business, they have to decide, but they have to be a citizen they have to decide.* (T8)

Regardless of the subject taught and with the purpose of training students for their future workplace, educators were reported to be students' role models in promoting responsible individual behaviour in their school community.

> *I see myself as being a citizen for our own school in a good example of what, how to set pupils and their skills apart.* […] *There's a whole host of things in our curriculum that enables us to give ideas to pupils how to take things forward and how to become responsible. All the health and wellbeing curricular areas that we're now involved with.* (T11)

A clear feature of this conception that emerged from the transcripts was the stated idea that students' integration in society must start with looking after their own bodies and with taking care of the environment in which they live. Therein lay the specificity, in their account, of the biology teachers who, as citizenship educators, are supposed to promote respect of life.

> *If they don't know how to look after themselves, how can they look after anything else? […] teaching, not only biology, but good citizenship within the context of biology, looking after themselves, looking after the plant life, the animal life, etc.* (T3)
>
> *When we teach the world of plants, we allow the pupils to grow their own plants from seeds and to nurture them and […] they can see that they're caring for the plants and the plants will grow properly.* (T5)

Democratic skills and impartialness of the teacher

If one of the central concept of this way of thinking was the asserted idea that students are first of all citizens of their own school and teachers are their role models who prepare them for their future working life, the biology classroom itself, meant as a community, was considered by the participants a training field for developing the skills that are at the basis of living democratically. This idea was explicit in a cluster of utterances in the second attribute of this conception. For instance, a participant's declared concern was the promotion of students' ability to express and develop opinions.

> *How you develop your social skills and interact with different people.* […] *So sometimes you have pupils in your class that have a completely different train of thought from yourself and you have to incorporate that into the lesson and take on board their opinions.* (T4)

Central to this way of thinking was the impartialness of the biology teacher. It was reported that students in their classroom must be free to make their own decisions and even to be wrong. Therefore, the impartial standpoint of the educators was considered important for developing rather than imposing ideas.

> *I think it's important not to put your views too much in, let them make their own decisions but give them the facts to decide themselves, it's the impartialness that's maybe difficult.* (T5)

> *I think giving them the knowledge that then they can take away and telling them the importance of their role in society by allowing them to make their own choices. The challenge, that I think is the most difficult, is trying not to over-emphasise my own opinion and allow the pupils to make their own decisions about what they think is right and wrong.* (T4)

A crucial pedagogical challenge for the teachers, within this way of thinking, was the need to avoid imposing their point of view and to include democratically every student in the debate.

> *So, they would go away and research a controversial topic such as stem cells and then, quite often, what I'll do is I'll give them an opinion so you're not really putting pressure on any individual pupil to see what they really think. So, I'll give them the role of a character and they have to portray their opinions.* (T4)

Understanding socioscientific issues

The impartialness of the biology teachers in their role of citizenship educators was also related to a group of statements that I clustered in the third attribute, featuring this way of conceiving the link between GCE and SB. Namely, the excerpts of the transcripts that encompassed the declared purpose to promote a basic, essential but adequate scientific literacy necessary for understanding the contemporary socioscientific issues.

> *I think to become a well-functioning citizen you need to be aware of – you do not have to be an expert in everything – but you have to be aware of certain things like the problems with waste or in the case of genetic engineering or population growth all these things to be able to come to your own decisions (T17)*
>
> *I think we still like to give them the chance to think for themselves and be responsible in their ideas. But it's also still important giving the facts and figures that we're able to do in our biology curriculum.* (T11)

The need to amalgamate the democratic right of the students to express their own ideas and opinions, including non-scientific beliefs, and the “established facts” of science, seemed to be an educational concern associated to this category of description.

> *Stem cells […] pollution […] healthy eating […] transplanting organs […] genetic engineering […] What do you think? What's the outcome of that? What's the ethics associated with it? Then think about the world, is that a good idea? Because a lot of them take in the theory for genetic engineering but they don't think of the consequences. They are just thinking about what they need to pass the exam as opposed to the wider picture.* (T7)

Participants seemed to suggest that school biology could provide students with the scientific literacy useful for interpreting and untangling the complicated set of information about socioscientific issues, such as cloning and genetically modified food.

> *Stem cell research because obviously, that is going to affect the pupils in terms of perhaps getting asked their views on it as they get older or voting on it or whatever. I do things on food security, so that affects them. Global warming, again, that affects the type of role that they are going to play. (T2)*

For the same purpose, participants maintained that they connected the biology curriculum with what is happening in the world in terms of contemporary scientific debates.

> *What we do in the class is read things like New Scientist, obviously watching the news and what not, so it is making them aware of relating what they are doing in the class to how that affects the outside world and how the outside world affects them.* (T2)

In addition, the idea was also suggested that biology teachers have a role in the individual development of the cognitive and the ethical dimension of young people, by discussing with students issues reported in the news.

> *There is a certain way to talk about everyday issues in the newspaper through biology* [...] *And all of a sudden you have this huge ethical dimension because if it is easy to revert an old cell back to a new cell then you could just kind of grow it and implant it* (T17)

> *I think actually the ethics are quite a big one [...] but also what the law says in terms of cloning. Can you clone yourself and those questions always come up.* (T16)

Multiculturalism and science

Finally, I labelled the fourth attribute of this conception with the term multiculturalism because it encompasses a group of excerpts in which the universality of the scientific language and the benefits related to multiculturalism were mentioned as a means for the biology teacher to promote GCE. One participant, for instance, argued that the universality of science is shown by the fact that many biology projects are made possible only for the international collaboration among scientists of different cultures.

> *We do ecology as well and to make these links with other countries but not just the country but the cultures and the way that science is a universal language, or should be.* [...] *The human genome project that was a universal project that so many countries combined in and was an incredible success in the way that people worked together (T19)*

A further related educational purpose suggested by the participants was that to promote collaborative work and thereby to raise the awareness of the dividing forces, such as sectarianism, which weaken the ability of human beings to work together for the resolution of shared problems.

> *To raise their awareness of what's going on, so if there's something happening which could be like sectarianism or something which could separate people. […] If everyone is working together you have a community which works towards a better cause.* (T7)

Their view was not only about merging different cultures and appreciating cultural differences. In fact, participants highlighted the need for making students aware of the relativity of their own culture, which is only one of many possible cultures. This way of thinking is related to the democratic training mentioned in a previous section and it is consistent with a multicultural CE. In fact, the educators' stated concern was about opening the mind of young people who, in spite of being in multicultural societies, are actually living in an environment that is culturally limited.

> *I feel it is too, initially within the school to make the links between the children as well, to be aware that the predominant culture is just one culture and for them to be aware of what these other students can bring to our classroom.* (T19)

> *It means making them aware that their local community isn't the only reality that there is, but there is also a wider reality, other realities which they should be aware of if they won't be travelling in their lives and won't be in contact with other populations in the world. I think they should be exposed to different cultures.* (T18)

> *Sometimes it is a surprise to our students to understand that things are the same in Poland as they are here. It is not a country that they can relate to easily […] I find that is quite challenging in this part of the world because the [geographic area] of Scotland is quite insular. I think it is important that the students learn there is a wider world out there and we try to relate what we are teaching them to something a bit beyond [name of the town].* (T21)

Global citizenship education was therefore seen as promoting the contact of students with other cultures, making students aware of the people living in other countries.

> *Trying to educate, to show our children in schools, to try and open up their minds to other cultures and to link them possibly with other ideas*

> *in other countries […] and being aware of the lives of other people in other cultures.* (T19)

5.2.4 Referential and the structural aspects of the Biology teachers' conceptions of global citizenship education

In the methodology chapter I mentioned that, in phenomenographic analysis, the unit of description consists of two intertwined aspects, the referential and the structural aspects. The former consists of the general meaning of the phenomenon conceptualised, the latter of the combination of features that the participants have focused on (Marton and Pong, 2005). The data gathered in this study reveals that there were essentially three different ways in which the biology teachers interviewed interpreted the link between GCE and SB. Their statements could be logically organised into three different patterns, which consist of the abovementioned three different conceptions. In this section, the referential and the structural aspects of each conception are discerned (table 5.5).

The statements constituting the first conception, which was labelled *Global justice*, were characterised by the common denominator of the social injustice. The social injustice of the global society, due to differences in access to food, water and medication, was the focus and the key motif in the assertions associated with this way of reporting the link between SB and GCE. The structural aspect of this conception is, therefore, the focus on the injustice in which biology was linked to the global systems of profit. In other words, the focus of participants' statements was on socio-economic and political issues, rather than on pedagogical aspects or on scientific literacy or on ecology per se. The general meaning of this conception is the implicit aim to develop the socio-political awareness of citizens in the context of biological themes. This is the referential aspect of the conception.

In relation to the second conception (i.e. *Environment Sustainability*), the structural aspect must be sought in the scientific perspectives on the relationship between human societies and environment. In fact, the focus of the participants' statements was on the environmental threats represented by the jeopardising impacts of human activities on present and future global environment, on climate change, on habitat destruction, on species extinction and on pollution. Therefore, the overall meaning of the second conception consists of the explicit purpose to promote, through SB, pro-environment behaviours in students and to develop their ecological conscience.

The final conception identified in my study, *Individual development*, had the overall meaning to develop the cognitive, ethical and democratic dimensions of students as citizens. In fact, the stated concerns of the participants were on multicultural sensitiveness, the democratic acceptance of different points of view and the provision of a scientific literacy useful for participating in SSI debates. The emphasis in this conception was on the development of personal aspects of citizenship, and de-emphasised the global aspect of GCE. The referential aspect of this conception consists in all the above. Therefore, its structural dimension was the focus on the individual students themselves viewed as young citizens who have to learn how to develop their own ideas about scientific and biological issues and how to interact democratically with others.

Conception	Referential Aspect	Structural Aspect
Global justice	Develop the political conscience of citizens	Social Justice
Environment sustainability	Develop the ecological conscience of citizens	Environmental Threats

Individual development	Develop the cognitive, democratic and ethical dimension of citizenship	Individual Students

Table 5.5 Different aspects constituting each conception emerged by exploring the link between SB and GCE as conceived by biology teachers

5.2.5 A summary of the findings of the first research question

The data of this study reveal three different ways of thinking and reporting on the role of the biology teachers in educating for GC. The first conception relates the biology syllabus to issues of social justice, the second to environmental issues, while the third focuses on the individual development of students. These three conceptions can be seen as a map of the collective mind of the secondary school biology teachers who participated in this study. Figure 5.1 represents this map in visual form, related to the possible ways of expressing conceptions of GCE through SB. Using word clouds, it is possible to see that educators within the social justice framework use the word ‘people’ more than any other. For those within the identity B the most commonly used words are ‘environment’ and ‘plants’ and finally, for those in framework is ‘pupils’.

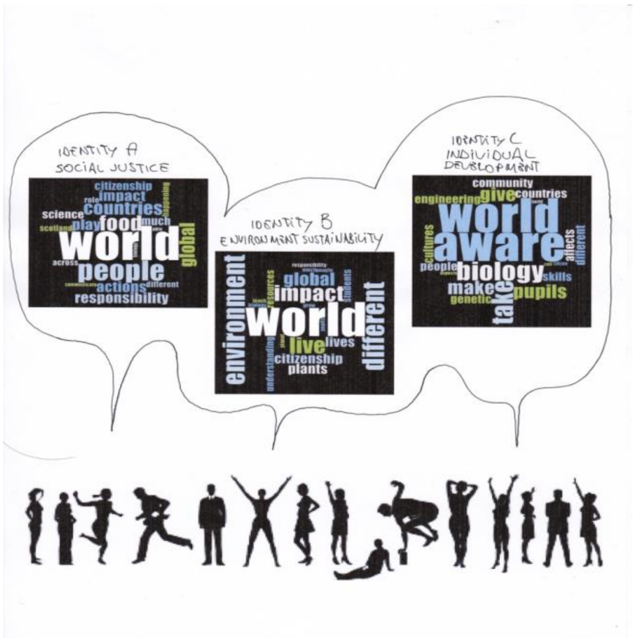

Figure 5.1 Collective mind of the participants through the word clouds

As I mentioned in the methodology chapter, the starting assumption of phenomenography is that for any given aspect of reality there is a limited number of ways in which the members of a group can understand it, interpret it and conceive it. Phenomenographic studies aim at understanding the different ways in which a group of people interpret an aspect of reality, rather than exploring the differences among the individual participants of the study (Orgill, 2012). Nonetheless, I show in the diagram in Figure 5.2 the relation between conceptions and individual participants for those readers who are interested in making inferences on the individual subjects.

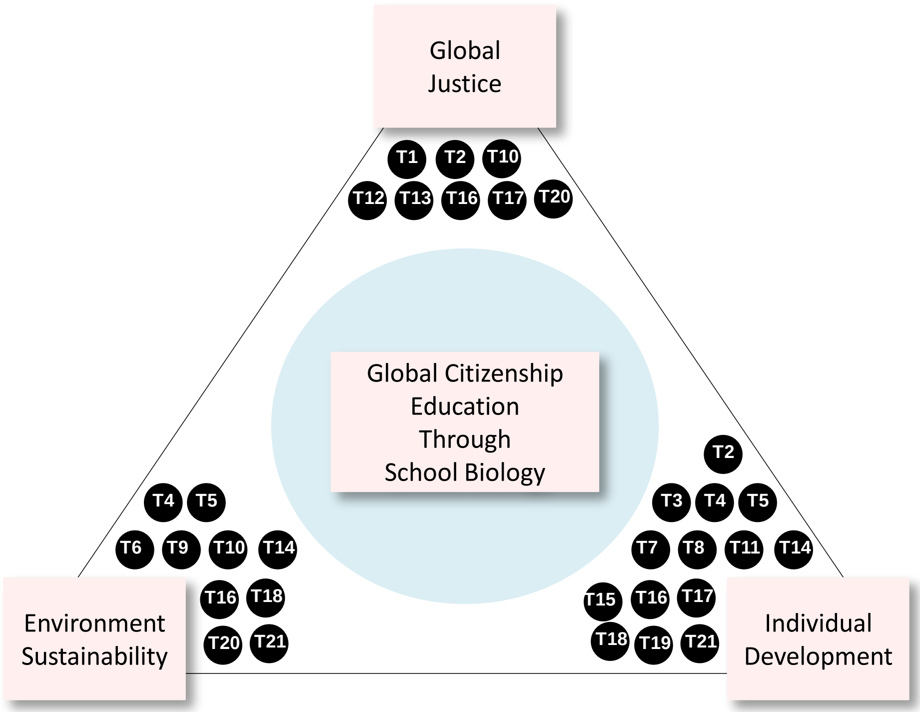

Figure 5.2 The triangle represents the relationship between GCE and SB and the three vertexes represent the three different conceptions. Inside the triangle, the codes represent the quotes reported in the previous sections

Figure 5.2 shows that several teachers maintained arguments that are consistent with more than one category of description. For instance, teacher 16 interpreted global citizenship through the concern with the demand for social justice (i.e. Identity A). She also maintained to involve her students in active learning strategies with the aim to develop their ethical and cognitive areas (i.e. Identity C) and she also declared to make students aware of the hazard associated with non- sustainable environmental choices (i.e. Identity B).

This finding is not surprising. Firstly, it is consistent with the literature which reports inter-contextual conceptual shift' (Marton and Pong, 2005, P.342). Namely, the use of more than one conception for a particular phenomenon by the participants in phenomenographic studies. Secondly, the categories of description are different ways of describing the interplay between SB and GCE. They do not label individuals, but they are ways of conceiving the link between

SB and GCE and represent a sort of 'map of the collective mind' (Orgill, 2012: p.2609) of the group of biology teachers who participated in the study.

5.3 Findings related to the research question: *what are biology teachers' conceptions of the link between Evolutionary Biology and Global Citizenship Education?*

Most of the participants in this study acknowledged a link between EB and GCE by recognising a role of evolution education in providing students with opportunities for exploring GC issues. The following excerpt is a case in point.

> *I guess, to see yourself as a global citizen and not just a citizen of Scotland or whatever, you need to have some sort of shared relationship or something in common with people in other countries. I think with evolutionary biology when you are teaching that you are saying we are all related so maybe it can give them that sort of context.* (T20)

In the following sections, I summarise the main categories of description emerged from the phenomenographic analysis, and revealed variation in the biology teachers' statements that can substantially be depicted by the same conceptions, describing the abovementioned three citizenship educator identities.

The first meaning is, in fact, well described by the last reported quotation. This meaning consists in the stated idea that EB makes real and biological the connections among the citizens of the world (i.e. conception 1, Global Justice). A second conception emerges from the participants' statements linking EB to the efforts to preserve the natural environment in which the citizens live (i.e. conception 2, Environment Sustainability). Finally, the third meaning is consistent with the participants' assertions about the relevance of EB as critical component of scientific literacy for understanding related SSI (i.e. conception 3, Individual Development). From section 5.3.1 to section 5.3.3, the three categories of description are described in detail, by providing also the raw data. Section 5.3.4 illustrates the referential and the structural aspects of each conception. Finally, section 5.3.5 explores the stated constrains in making the link between EB and GCE real, as they are described by the participants.

5.3.1 Conception 1: Evolutionary biology for Global Justice

Conception 1 consists essentially of the stated idea that the teaching of Common Ancestor Theory and the biological homogeneity of our species can be a means to develop a common sense of belonging to humanity.

> *R: what themes within evolutionary biology specifically do you think may have links with global citizenship?*
>
> *Evolution – the best thing about teaching evolution, I do love teaching evolution, is the core factor that we are all related. And that differences between people are miniscule.* (T17)
>
> *R: What do you perceive as the constraints on this* [linking EB to GCE]*?*
>
> *I think for global citizenship it is that accepting of other people, other cultures and knowing that we are all essentially the same we are just evolved in a slightly different way but we can work together and work to our strengths. It is time that is a really major thing because it is something that really needs to be discussed, you can't just pass over it.* (T12)
>
> *R: what opportunities do the themes of evolution, race and gender provide for the student to explore citizenship issues?*
>
> *I would like to think the children in my class once they have maybe understood a bit more about the science behind it then they can show more empathy and that would help with citizenship.* (T13)
>
> *Because there are natural ancestors there, I think it helps to cement it and make you feel like a global citizen rather than just a Scottish citizen.* […] *So, in terms of with the rest of humanity I think it helps them kind of build those bridges and make them no so isolated and kind of go actually we have these links across the world.* (T16)

Table 5.6 is a summary of the attributes of this conception.

Conception	Attributes	Participants
EB for Global Justice	Connecting everybody	T 1, T2, T6, T12, T13, T16, T17
	Negligibility of human biological differences	T8, T12, T13, T14, T17, T19, T21
	Issues of racism, sexism, migration and human rights	T1, T2, T3 T7, T12, T13, T14, T16, T17, T19, T21
	Promoting a non-hierarchical view of nature and empathy for other living beings	T1, T2, T7, T12, T14, T16, T17, T21

Table 5.6 Summary of the attributes constituting the conception *EB for Global Justice*

Connecting everybody

A clear attribute of this category of description emerged as a cluster in participants' statements highlighting the potential value of evolution education in making real the connections among people around the world. The following excerpts, with those which preceded the table, are a case in point.

> *R: Now thinking more specifically to evolutionary biology – two or three questions about evolutionary biology. First of all, what themes within evolutionary biology specifically do you think may have links with global citizenship?*
>
> *I think evolutionary biology has a really important place. It makes pupils realise that even though somebody looks very different to them and lives on the other side of the world that there is a link there and it makes it a bit more personal.* […] *Now we do know about the DNA and finding their ancestral roots might change the way that they think about how they are viewed globally.* (T16)
>
> *Evolutionary biology shows us how effectively we have a common ancestor and we have adapted to our circumstances. When you look at that across everybody in the world it is a good way to appreciate that we are different but we are all also from the same roots and we have adapted to different circumstances. But it is not that we are completely different we are still essentially the same people.* (T12)

> *Evolutionary biology explains that the human species is not that old. We are about a hundred thousand years old and that we are all very closely related. And that our perceived differences are mainly cultural but that the differences as humans the way we are think and our wishes for our lives are very similar. And that some of the differences physically are only extremely minor.* (T17)

> *Evolution biology shows you how we're connected, not only as you know human race how we're connected over the world, but also connected to the natural world.* (T1)

> *There are always one or two points where I know the kids will go "what". The fact that I can point to any of my children, we are related. Somewhere along the line we have a certain great-great-grandfather that we have in common. Same with me and you. Same with them and some kind of rats or jellyfish.* (T17)

> *… understanding the difference between species and the different ethnic groups and the origins of people and all those concepts are fascinating and could make a huge difference to how we behave towards each other and how we treat each other and how we understand each other's backgrounds and belief systems and beings* (T6)

Negligibility of human biological differences

A second attribute emerged from the participants' statements that argued for the negligibility of the biological differences in our species. The following quotations are only a fraction of the statements arguing for the genetic equality of humanity when the participants were asked to discuss the relationship between EB and GCE.

> *There is no one person is better or worse than the rest of, we're all the same, we've just got different traits.* (T1)

> *You can say that [people] has changed slightly because of the situations that are there but that doesn't actually make the core person different and I think understanding differences is just as much of an important thing as accepting them sometimes.* (T12)

> *When you appreciate just how much of our genetics are the same then you are talking about different ethnic groups, it is very subtle differences in the overall genetics. So that might break down a few barriers saying that everyone is completely different when you are in fact not.* (T12)

> *I think you could argue there that there is more of an understanding of different races and that is just literally an adaption to sunlight.* (T13)

Just being a single gene or a group of genes that are affecting that [colour of skin]. I think that can maybe help again in the same way of just seeing people as people and not very different from me. (T14)

Often the differences are maybe tiny little parts of one chromosome. So again, understanding genetics and understanding that the differences between people are very small. And often there is more variation within populations than your average difference between two distinct populations. (T17)

I think it could be very powerful for understanding that is just different base codes and that is all the difference is. The protein you produce is slightly different and therefore that it is. (T13)

We are able to study tiny differences and I think the older pupils are quite amazed that tiny base differences are all that it takes to make somebody a different colour or things like that. (T19)

So many people do not understand genetics and maybe that is why we have so many conflicts between different races and different groups. As I said before if ninety-nine per cent of our DNA is the same then we are the same people. (T21)

Obviously, genetics everybody's the same, like genetically everybody is the same, that's what I teach my kids, so I don't know about you know, anything else, but everybody is the same [...] *Genetically black, white, blonde hair, red hair, we're all genetically the same.* (T8)

Issues of racism, sexism, migration and human rights

A third group of statements made by the participants had as a common denominator the suggestion that EB can provide the scientific literacy for understanding a range of issues affecting our societies, from racism to migration. For instance, when discussing the link between EB and GCE, some participants claimed that EB is relevant in tackling racism and barriers between people and that, ultimately, there is nothing wrong in the genes of the poor populations.

R: What opportunities do the themes of evolution, race and gender provide for students to explore citizenship issues?

It allows them to clearly look at it from a genetics and evolutionary point of view what the differences are and to see that they are really quite small in the overall make-up of who we are. I think that is the main thing with all of those, you have got this much information and you have got this tiny little part that changes something about you and there are lots of unseen changes and essentially you are just who you *are and if knowing more about it and discussing it can help any barriers be broken down.* (T12)

R: In your view, how does biology and in particular evolution in biology influence our understanding of our relationship with the rest of humanity

I think young people need to understand that we all basically came from the same place and we are never going to get over all the kind of negative views have that young people can have of other people around the world if we do not understand that we all actually came from the same place. (T14)

R: in your personal view, are there themes of evolutionary biology that may have links with global citizenship?

We have descended from whatever" then that moment is quite a 'boom' for a lot of pupils but it is also beneficial because you can relate to the fact that we are all related and that is where genetics is really useful so when you are trying to talk about things like racism or all of these different - we are all the same so when you look at evolutionary biology and the genetics of it and that is really useful. (T2)

R: Do you think that the common origin has a link with global citizenship education.

I think the idea of hierarchy and one person being better than another if they realised that ancestrally that we are all the same. I think then that would hopefully remove that barrier and stop them either being you know I am better than them or you know they cannot do this. It would remove that barrier which sometimes I think pupils have. (T16)

R: In your view how does evolutionary biology influence our understanding of our relationship with the rest of humanity?

Well I suppose if we have all come from the same ancestor it should make us understand that we are all the same. And therefore, it should reduce prejudice should it not, I would think. (T21)

We have got variation following on from that so we have got the idea that they are all similar, but different, and that no one is necessarily better than one another. I think that's the thing you would have to give to kids to take home. (T7)

I think we need to understand the genetics as an entirety to understand that this is not something specific just to them ['underdeveloped' countries] that everybody could be affected by that same thing. […] we're talking about underdeveloped countries and the fact that there are problems that affect ethnic groups that we have not, as yet, encountered, but that doesn't mean we couldn't. (T3)

Related to the previous attribute, a group of participants' assertions seemed to express the related idea that EB can provide the scientific literacy for challenging the stereotypical concept of gender differences.

> *I certainly wouldn't say there was a big difference between male and females. Girls get an X from their dad and the fact you are telling them it comes from your dad or it comes from your mum makes you start to think well, it's a mix of genetic. It's not the information you are given that makes you different.* (T7)

> *You are for the very most part the same and there is that little bit missing off the Y chromosome that makes you different. I suppose there is that again you have got this mass of genetic information and just a small difference and talking about sex link variation and things like that probably help take down some of the barriers that are there.* (T12)

> *And you have this very interesting grey area that we should explore and come to understand so that people are not that set upon you should either be male and heterosexual or female and heterosexual. But there is also this grey area in between which has a totally rational genetic biological basis. Again hopefully it should make people more open-minded to other people.* (T17)

> *I usually do a bit on telling them all about testosterone and how the basic pattern is female and the genetics kicks in at six weeks.* (T13)

> *I did talk to them quite a bit of the time that there is a spectrum if sexuality. They are really interested because obviously at that time in their lives it is just fascinating. […] I think you can open up people's minds but it can also make pupils see that is not just down to science as well and you have got to realise there is a social aspect and in society that we can't assume that what is normal is male and what is normal is female.* (T19)

> *We quite often have discussions with the senior students about the fact that it is not as straightforward as male/female that there are differences which can influence gender.* (T21)

> *I don't want them to think that there is a gene for homosexuality so if you could do gene therapy you could replace that. I think that is wrong to suggest that to pupils as well because it is more than that.* (T19)

> *Kids can be quite cruel because they don't like anything that is different so you are trying to help them understand that there is more than just male and female in the world. It is more diverse than that so whether it is the colour of your skin, your gender, your orientation, whatever it is then that is what you want. You want the pupils to appreciate that it is a diverse world that we live in so I think genetics gives you that kind of angle to get in with that.* (T2)

Another facet of this attribute characterising this way of thinking was provided by the group of participants' statements arguing for a link between EB and migration, as a topical aspect of GCE.

> *So, the idea of immigration and emigration I think it is really interesting as well for that to show that this has always gone on, it is a process that will always go on and with the changes in climate this is going to become an issue as well.* (T19)

> *We are all human and see ourselves in a common way rather than seeing ourselves as being so different as maybe children sometimes can do. That leads to tensions which does not help when you see on the television that the government does not really want Romanians and Bulgarians to come here and all that kind of stuff. In-built in what a lot of children are seeing all the time is building up misunderstandings that are not encouraging them to see everybody in the world as being really the same.* (T14)

> *Massive, I think the opportunities are there for them to come up with some really interesting questions about who they are in the world and make them think a little about if we are genetically related, particularly linked to things in the news to do with immigration and why should certain people be excluded and other people welcomed in?* (T19)

Participants also linked EB to another possible topical aspect of GCE, namely the universality of human rights.

> *I think the idea of a being a global citizen. I link that very closely to human rights. I do not know whether that is correct in my head but because I link that very closely to human rights I think the evolutionary side makes them think no one is born this, this and this.* […] *I think it makes them realise that we are all equal.* (T16)

> *And you should not just throw it away by fighting or slagging each other off or different culture or different skin or different sexuality or whatever and that you should just see life as a unique thing and just enjoy your seventy or eighty years that you have on the planet.* (T17)

> *I think it just opens up that whole debate of what is a citizen, what are your rights. Does it matter whether you are male or female? Should you both get the same rights? Where does that not happen? In terms of your race should you be able to do everything else that everyone else does? I think it gives opportunities of things like discussion and debate.* (T16)

Promoting a non-hierarchical view of nature and empathy for other living beings

The following quotes are grouped in the same attribute because they all indicate EB as a tool for challenging students' anthropocentrism and for possibly promoting a non-hierarchical view of nature and empathy for other living beings.

> *It is just being able to make that link, help the children make that link, between the fact that whether it is a human or whether it is an animal, we are all related and, to me, that is the beauty of biology because we have things in common with an ant or a tomato or a banana. We have 50% of the genetics of a banana!* (T2)

> *I think often people are surprised if I teach aspects of this course and I say that humans are animals. That shocks a lot of children because they do not actually see that. They think humans are somehow separate from that and are a level above. Trying to show that actually we are not we are on a continuum and it just so happens that we ended up at this end of the branch of evolution whereas others have gone down a different branches [...] it puts things in a context where everything is living and you just happen to be a human and that just happens to be an oak tree.* (T14)

> *Connections with them; tree of life - we're all connected, we're all from the same source.* (T5)

> *Then you are just a part in the whole thing. You have come from apes as well so we are not the beings all and end all.* (T7)

> *We do the human genome project and we discuss the fact that a very small part of our DNA is actually different from other organisms which is something they find very surprising. So, I guess it may be helps us to understand that we are not really superior to anything although that is possibly a common thought.* (T21)

> *All species have evolved to perfection in their environment.* (T12)

> *I think it is really key for other living beings in the planet, the idea that actually the primates and all the species that are around today are as advanced as we are. I think pupils really struggle with that. They have the preconception that when the monkey evolves enough it will eventually turn into a human. It is a very big misconception that as teachers we have to debunk.* (T16)

> *There is definitely people out there who has sort of hierarchical view of the natural world, especially, I mean I guess it depends of the reputation of the bible as well, that god created man and also created the natural world for man. So it depends on your interpretation of where, for me we're all on the same level.* [...] *because my understanding of evolutionary biology is that is shows how we're all connected as one. Not only to humans, to one another, but to the*

> *natural world outside you know, how we've evolved from primates and how we've evolved from simpler beings.* (T1)
>
> *I suppose if we take it in terms of evolution then we are linking it to other citizens of the planet if you like are we not, animals, I do not know if you could call a plant a citizen of the planet.* (T21)
>
> *Same thing in the sense that I said earlier that the fact that we are all related. You can also speak if you speak about animal welfare for instance, if you talk about the suffering of pigs, or cows or other mammals in the evolutionary tree we are very close. We have very similar kinds of pain responses and even though I do not have to physically put myself into the mind of a pig to understand what the pig will feel if it is being slaughtered or something because it has the same kind of system that we do. And so you can talk about animal welfare issues very much in that context. (T17)*

5.3.2 Conception 2: Evolutionary Biology for Environment Sustainability

This understanding of the link between EB and GCE emerged by grouping the participants' statements that highlight the relevance of EB to the issues of biodiversity and ecosystems and thus are related to the natural environment in which the citizens live. Table 5.7 lists attributes and participants associated to this category of description.

Conception 2	Attributes	Participant
EB for Environmental Sustainability	Learning from Natural History	T4, T5, T11, T12
	Responsibility for future generations	T3, T4, T20
	Understanding biodiversity	T4, T12, T13, T16, T17, T19, T21
	Understanding human impact risks	T2, T3, T4, T9, T13, T16, T19

Table 5.7 Summary of the attributes constituting the conception *EB for Environmental Sustainability*

Learning from Natural History

A feature of this way of thinking was the stated educational purpose to provide students with the notion that is key for understanding the call for environmental sustainability, that all living species are fragile adaptations to temporary environments and the result of a long evolutionary history.

> *R: What themes specifically in evolutionary biology do you think may have link with global citizenship?*
>
> *The pupils need to have an awareness of we haven't just existed as we always are and it's our job to show them what happened way back and very much be aware of where we're going to go. It's like everything, it's like three levels, isn't it, it's like the history of it, where we are now and where it might be going?* (T11)
>
> *The world's constantly changing and evolving. Knowing how the planet has evolved will help us in the future to conserve.* (T4)
>
> *I think the more we know about where we came from and from the past, then we can see how to proceed in the future, evolutionary biology helps with the conservation and knowing where an animal came from perhaps, keep it in a habitat where it should be and where it can thrive. So, in a conservationist front there's a lot evolutionary biology can offer.* (T5)
>
> *I think really the thing that has to be focused on is our impact, the fact that these other species have evolved to perfection in their environment and just small changes that we make just blundering through the world can have a huge impact on them. I think knowing just the small changes through each stage of evolution that can make or break whether a species survives or becomes endangered and extinct.* (T12)

Responsibility for future generations

The stated responsibility for future generations was precisely a second key feature related to this conception that emerged from those utterances that were arguing for the need to educate for preserving the environment.

> *R: How does evolutionary biology influence our understanding of our relationship with other living beings of the planet?*
>
> *Thinking about evolutionary biology I think humans still tend to think of ourselves as quite separate from other organisms. Even sometimes in third and fourth year they forget they are animals so even though you have got some understanding of evolution I think people still tend to see themselves as separate.* […] *I think learning about that gives us*

a good understanding of the relationship, I think that is very important. Especially for the next generation, we have got a bit of a mess with the planet and to understand that everything is interdependent. (T20)

You need to know where you've come from, how the environment has changed over the years and that can help you make decisions about your role as a human and how you can live your life accordingly to ensure that the environment that you live in is kept for the generations to come after you. (T4)

Even as far as politicians are concerned and how they make decisions about the world we live in, so we need to know from our past and learn the lessons in order to frame the future. (T3)

Now we're more aware of our influence and how we can put things into place to try and protect animal and plant species from becoming endangered, how to conserve them, the gene banks and the seed banks, things like that nowadays. (T4)

Understanding biodiversity

An assumption of this way of thinking found in the data and emerging from a distinctive group of statements was the idea that EB is fundamental for understanding events in the history of the Earth and the mechanisms that generate and maintain the biodiversity of our planet.

R: What themes within biology do you think may have links with global citizenship?

Thinking about adaptations, natural selection we always use the Galapagos Islands and then we talk about should we actually preserve them. Things like in Brazil I know it has stopped at the minute but cutting down of the rain forests and habitat destruction. (T16)

I'm not sure how to answer this properly. This is because I haven't really started the biodiversity topic, which is the part of biology, which I think may help linking evolutionary biology with global citizenship. (T18)

In the first year they also have no idea what evolution is but it does not really come until third or fourth year. Once they have an understanding of evolution, we go biodiversity, and then it is easier to explain. I definitely think evolution should be coming far earlier. (T17)

I think the idea of where we have come from as human beings so human evolution and then the idea of speciation in general, the distribution of organisms. (T19)

Evolution education was also seen as a means for understanding that those mechanisms that maintain the biodiversity of our planet consist also in the interdependence of all living beings, including humanity, as an integrated part of nature.

> *I think it* [evolutionary biology] *shows the complex interdependence of different organisms. It can also show through things like symbiosis the interactions that organisms have which other.* (T13)

> *When we talk about biodiversity, sometimes the pupils are quite surprised because they have never thought that without plants we could not exist. They see themselves obviously as being something completely different to a plant, which they are but on a much higher level than a piece of grass or a dandelion. It should help us to understand that the word "relationship" is a key in that sentence is it not?* (T21)

> *If you take organisms out how does that evolve and how would you change things. They find that quite hard to understand at first but then once they understand that there is an impact and ramification on that because they quite often think they are not directly connected then getting them to understand everything is ultimately connected to each other and everything lives in a complex homeostasis balance.* (T13)

Understanding human impact risks

Finally, closely linked to the previous, a further attribute emerged from those participants that depicted the study of EB as a critical component of scientific literacy for making students aware of the threat represented by the increase of human demographic growth and from the damaging impact of our activities on the ecosystems of the planet.

> *I think that made them realise actually that we have a responsibility and it is because man – a global population increase has had such a big impact. In terms of evolutionary biology, I think it has got a really strong key point to do with other animals on the planet and other organisms and again talking about the rain forest and other habits being destroyed because actually our population is increasing so we need to take up more and more space that idea so I think that is a really big influence.* (T16)

> *I think that is an important point to get through that it is fragile, we have come so far in evolution and other species have evolved in different ways but it is still a very fragile relationship that we all have, I think that would be quite important.* (T12)

> *It is from human activities so I think to get an understanding of evolution from natural selection and then use how human beings have then led organisms on different evolutionary pathways […] Examples that we use are heavy metal tolerance in plants, the evolution of this is natural selection very quick changes but heavy metal, where have they come from? (T19)*

Within this way of thinking the participants argued for the purpose to promote, through evolution education, agency, environmental responsibility and students' awareness that their behaviours can affect changes in the environment, if not the fate of the world.

> *Like our overall consumption of everything, can affect food supplies, and basically, we're being too greedy and using up things, and that's affecting the rest of the planet I suppose.* (T9)

> *I think like speciation, but obviously within it you can talk about biodiversity and the idea that you need stable ecosystems and they have all evolved from common ancestors and why you need variety of medicines and you need variety of different things and the impact it has on people if we start taking up the rainforest.* (T13)

> *Throughout the world everything is changing all the time and you can have an impact on that as well. As well as other people the impact that you can have on the environment in a local way and in a global way.* (T19)

> *I always tell the pupils that they are the future and the planet will depend on them and the knowledge they pass on to their children and their grandchildren, so knowing how we've evolved up until now may help with it.* (T4)

> *I do actually say that to the kids in terms of it is our relationship with the planet and the things that live in it and we have got a responsibility to use it well.* (T2)

> *We do have to think about how we impact on other living beings and so, as far as we're concerned, and the school, with biology we try to enforce - that's the wrong word - we try to impact on the review the necessity for their behaviour and how it impacts on other things, you can't do any more than that.* (T3)

> *That's all related to the environment and how animals are adapted to the environment, and, well yeah, the changing environment is going to have an effect on our animals and plants. So, it'll affect us because we rely on them.* (T9)

5.3.3 Conception 3: Evolutionary Biology for Individual Development

The overall meaning of the third conception on the link between school EB and GCE emerged from those participants' statements collected in the attribute listed in the table 5.8 and arguing in favour of promoting responsible participation in society, informed participation in the socioscientific debates and democratic sensitiveness for multiculturalism.

Conception 3	Attributes	Participant
EB for Individual Development	Understanding the value of life	T3, T5, T14
	Counteracting ignorance	T3, T5, T7, T14
	Understanding the NOS and the SSI	T2, T5, T6, T8, T11, T13, T16, T17, T19
	Multicultural Sensitiveness	T2, T4, T6, T7, T11, T13, T15, T18, T19, T21

Table 5.8 Summary of the attributes constituting the conception *EB for Individual Development*, in relation to the link between EB and GCE

Understanding the value of life

The first feature classified in this conception was revealed from the stated participants' argument that EB makes students appreciate the meaning and the value of life itself, as a fragile process constrained by chance.

> *R: What are the implications of genetics in your view for our understanding of the relationship between the human races and ethnic groups*
>
> *[…] that just being a single gene or a group of genes that are affecting that […] I think sometimes as well one of the things that I would like to use to teach evolutionary biology is just giving them an understanding of how amazing it is that they are here in the first place. And just how amazing it is that they are here and fit and healthy because it is so easy for errors to happen at all sorts of places along that road of them becoming an individual. It is amazing that we have got so many fit, healthy and hearty human beings on the planet.* (T14)

EB was, for example, reported to be necessary for providing citizens with the understanding of the fragility of human life and of the potential global threat that antibiotic resistance poses to humanity. This understanding, according to the participants' statements, was critical for scientific literacy, in order to promote responsible behaviour in the use of antibiotic treatments.

> *Antibiotic resistance is a massive problem. Especially now in fact almost every time we talk about it now, I inform the pupils about if hey're given a course of antibiotics they've got to complete them because this is what can happen and so on and so on; so, trying to bring that up. I think you've got to inform them. (T3)*

Counteracting ignorance

EB-based understandings were also reported by the participants to be a means for overcoming ignorance and superstition, with the aim to promote the inclusiveness in society of people with genetic diseases.

> *I think you've got to inform them of things so they're absolutely aware of people who have, perhaps, Downs Syndrome, they're maybe not as aware of other mutations that occur within the human population so they have to be aware of them.* (T3)

You go back 100 years, a Downs baby would just have been left out in the cold sort of thing because it's a curse or a sin or something like that, so understanding that it is just a trick of nature that maybe we could be more accepting of people and help them. (T5)

It's one gene that's making you different. It's one gene that makes you different from someone with cystic fibrosis or Downs syndrome. There's one thing that's making you different that might give you an evolutionary advantage but it doesn't make you different as in today's society, so you are all treated fairly. (T7)

Understanding why somebody might have a condition that makes, for example, I suppose the most obvious one would be Down Syndrome where often young people would see that almost as a non-person and just explaining why that child has that condition and how a small thing has happened to make that happen. (T14)

Understanding the NOS and the SSI

The third attribute featuring this conception collects all participants' statements linking EB to understanding of the Nature of Science and SSI. Understanding of EB was viewed as a pedagogical device for challenging students' beliefs and for integrating science into their insights of the world. Participants reported that debating with students the theory of evolution could, for example, improve their understanding of what NOS is.

R: I'd like to talk about if in your view there are any issues, tensions, difficulties that arise in the classroom when you address themes of evolution and genetics related to our species

That is what school is about. It is about challenging what you believe based on fact and then letting them make up their own mind. […] *My view is that you teach the science, this is a theory and then the pupils are left with the idea that we will present information to you as an accepted theory and then it is up to you to make your own mind up in terms of religious beliefs.* (T2)

Obviously, there are controversial issues within that, there are some pupils that have a very strong faith and I just believe that I am teaching evolution and I am not going to get involved in teaching any alternative theories. (T19)

I think the Catholic Church even came out and said evolution is real, a few years ago. It didn't get very much publicity but that was quite big, major from them in terms of the acceptance that "Yes, this is real". (T2)

I think it is a very good scaffold because you are dealing with data so you are trying to remove the emotions. But there is a place for the

> *emotions and we do try and help emotional intelligence and get pupils to think outside of the box. I think there is a place where because doing it in science helps it not be so viewed by the emotions that you can look at the data and you can look at it and that will hopefully change your perceptions.* (T16)

> *It* [theory of evolution] *is provable by empirical evidence so it is not likely to change much, if at all. Some children struggle with that idea, that notion.* (T2)

> *I don't think evolution is unproven, I don't think it's ungodly to believe in evolution.* (T8)

EB was also regarded by the participants particularly useful in the debate on SSI and for developing the ethical and the critical dimensions of students.

> *It is making them informed citizens to help make better decisions themselves later on health care, genomic medicine so that they have information about their genetic sequence.* (T19)

> *In first and second year, we do a lot of debates on citizenship issues so it can be things like designer babies and DNA profiling and forensics and thinking about the ramifications of if one child is born for bone marrow for another child and the ethics and the appropriateness of that.* (T13)

> *The fact that we are very closely related, it does not just mean we are closely related on the family tree but also our body systems work very similarly and therefore you should respect the fact that they* [animals] *also feel pain and that as a human being more human beings should try everything to try and reduce that.* (T17)

Some teachers, for instance, maintained that understanding of EB was critical for participating in all those debates related to the manipulation of DNA of other species.

> *I think there are some big issues there especially with evolution and the whole theory of evolution - it's not necessarily what it says in the Bible sort of thing. And even with genetics we are playing God more and more when it comes to genetics and genetic modifications and ears on the back of mice and things like that. It's trying to explain the necessity of this while being sensitive to other peoples' beliefs, how they view them.* (T5)

> [EB] *helps to understand how we can impact on them* [other living beings]*, how they will have influenced us, how the way that we can influence can change, can manipulate different species for our own*

> *gain. It hopefully can make us consider how we do that for the future.* (T6)

Participants' statements also highlighted the importance of studying EB-related topics for informing students, as future citizens, about the benefits that result from the applications of EB understanding. In particular, the improvements in food technology, having the potential to solve one of the oldest problem of humanity, that is world hunger, was viewed as a crucial EB-related topic in educating for citizenship.

> *It is towards genetics and the influence on the genome and genetically modified foods and those sorts of things, gene manipulation, global food supply and the impact that genomic research can have on that.* (T6)

> *How is our population growth affecting our ability to grow plants and then linking that into modifying organisms. So, genetic engineering of organisms can help feed this increasing population. (T19)*

In the narration of the participants, EB-related topics were also described as thought-provoking and crucial for debating with students the bioethical dilemmas related to human DNA manipulation and the potential impact on the demographic features of a population that would result from "improving" the human genome.

> [The students] *like the idea, they like to learn about our different programmes of how we can alter gender depending on picking the right egg and sperm etc, they can manipulate it and people can choose what gender they want to have in their child. That's again, we're moving with the times again aren't we because there's a lot of people are able to do that and pick what colour of hair and eye that their child's going to have.* (T11)

> *As genetic engineering becomes more and more there's different genetic things happen, different basis, but if it's a problem in, say, one ethnic group, you might find the answer in another ethnic group to be able to switch the gene back to a better gene. (T5)*

One argument consisted in highlighting the efficacy, within CE, of showing on the one hand how the applications of this field of biology can improve human life and, on the other hand, the ethical issues raised by these applications. For instance, posing the question of whether the modification of human genes should be pursued, related biology also with the history of the bio-citizenship projects of the past.

> *The genetics is quite interesting then with the idea of eugenics when you start bringing up should we be able to manipulate the genome of a human being to get rid of horrible diseases. It is interesting because some of them don't question, of course it would be the right thing to do, it would be great to genetically manipulate organisms to get rid of suffering but they don't say that links to history with eugenics and Nazis.* (T19)

From the transcripts, it resulted that the integration of EB in the students' basic scientific literacy was considered by the participants to be beneficial in that it provides the students with the knowledge required to make informed choices and to develop a balanced view of the world.

> *They will have an opinion in the future as citizens of the world. To be informed about these things and if they have an understanding of what a gene is, what evolution is then hopefully it will make them more informed citizens when they come to vote on certain things, they are going to be in quite a different environment in thirty years I think the world will be quite a different place.* (T19)

> *That is the beginnings of the bit of knowledge that helps these children and adults have better, more balanced views of the world.* (T2)

Multicultural Sensitiveness

The last attribute characterising conception 3 emerged from a group of participants' statements concerned with multicultural sensitiveness and the confidence in the constructivist pedagogical approaches in teaching science.

> *You have to take into account different backgrounds of pupils who you are teaching and make sure that you're providing lessons that are suitable for every individual and that you're not giving your opinion; you need to take a back-step and allow them to make their own informed decisions.* (T4, p.28)

> *It is a theory based on fact evolution but you have to also be open to the allowance. It is a bit like this idea of a global citizenship in that everybody's views are important and what they feel is important.* (T2, p.18)

In line with the concern with a multicultural sensitiveness, EB was viewed as a school subject particularly useful in promoting interdisciplinary approaches.

> *Evolutionary biology comes into the religious education subject as well. So, we had to have quite good connections starting making the connection between that department and our own biology department. This is quite an exciting thing and it's happened across geography as well.* (T11, p.12)

In the relation between EB to CE, the first asserted concern related to the multicultural sensitiveness consisted in the declared democratic attitude of the appreciation of diverse views.

> *Given an idea that different people have different opinions on it, so you could come from Jewish backgrounds and it's different from what we think. That you have to appreciate other peoples' views as well.* (T7, p.9)
>
> *First of all in the class there are a lot of different cultures so you have to be very careful to what you say, how you say it and how you set up your teaching.* (T18, p.8)
>
> *When you're talking about dominant and recessive characteristics and some children might comment that they have a characteristic that neither parent has and you have to be very sensitive when teaching genetics.* (T4, p.28)
>
> *That you need to be very sensitive to people's beliefs and obviously science has got one viewpoint but there are people in your class who have a different viewpoint and you need to be sensitive to that.* (T13, p.7)
>
> *It is* [the difficulty] *developing the themes appropriately I think and not to then make people feel isolated because of their cultural backgrounds in reference to things like their belief in evolution.* (T19, p.16)
>
> *School in particular are places where you have to be very politically correct about what you say and how you say it so it might be something more discussed in social education with guidance staff than it would be in biology.* (T21, p.10)

In these participants' statements, the constructivist pedagogical approaches to teaching these aspects of science were viewed as a panacea for all the problems of nonacceptance and misconceiving evolution by part of the students' population. In this, the reported role of the biology educator was to provide students with the scientific literacy on which, by promoting independent study and active learning, the students are supposed to build their own views.

> *R: What themes do you think in Evolutionary Biology specifically have links with global citizenship?*
>
> *Evolutionary Biology - we teach the pupils about Darwin's Theory of Evolution and, obviously, some people believe it, some people don't and by doing research on the topic pupils can come to their own views on whether they believe it or not.* (T15)
>
> *So biology has got a pivotal point there to make sure that they have the biology there. As I say I think we still like to give them the chance to think for themselves and be responsible in their ideas. But it's also still important giving the facts and figures that we're able to do in our biology curriculum.* (T11)
>
> *So that you could even take it as evolutionary biology, they could go and do a small project on their own to see what someone else might think.* (T7)
>
> *It obviously goes with our timescale of our courses but it's probably something that we can use home research for, for our pupils, they can go and research about themselves perhaps and come up with their own opinions.* (T11)

5.3.4 Referential and Structural aspects of Teachers' Conceptions of the interplay between Evolutionary Biology and Global Citizenship Education

In the previous section I described how the phenomenographic analysis of the transcripts reveals different meanings of the interplay between EB and GCE and how these meanings can be clustered in three different categories depicting participants' ways of conceiving GCE in their role as secondary school biology teachers. These three conceptions represent the map of the collective mind of the secondary school biology teachers who participated in this study. In this section I describe the two intertwined aspects, of each conception, the referential and the structural aspects which are summarised in the following table.

Conception	Referential Aspect	Structural Aspect

EB for Global justice	Empathy/Connecting people	EB as a science
EB for Environment sustainability	Ecological sustainability	EB as a science
EB for Individual development	Develop the individual	EB as a school subject

Table 5.9 Referential and structural aspect for the conceptions emerged from the phenomenographic analysis

In discussing the interplay between EB and GCE, participants in this study focused either on EB as a science or on EB as a school subject. In both conception 1 and 2, EB was viewed as a natural science that can inform the scientific literacy of students and citizens. The structural aspect of the conception *Global Justice* consists of the focus of participants' statements on the Theory Common Descent and the advances in genomics. In fact, the understandings of EB were viewed as catalysts in linking school biology with GCE. The overall meaning of this link is indeed its potential to make real the connection between the people and all the other living beings of this planet, facilitating in students the development of human empathy.

The structural aspect of the second conception is EB as a science, its focus being on the Darwinian theory of Adaptation and its implications in the understanding of biodiversity. The declared purpose of the participants within this framework was to promote knowledge useful for understanding the ecological aspects of the natural environment in which citizens live. This was perceived as necessary for maintaining the health of the natural world. Therefore, the overall meaning of this conception is the need for citizens to understand the relation between humanity and Nature in order to exploit the environment in a sustainable way and to preserve it for future generations.

On the other hand, the overall meaning of the third conception is the purpose to promote the individual development by educating the students for GC also through school EB. The focus of the participants' statements was on EB as a school subject to be taught by using a constructivist approach and with cultural sensitiveness. In fact, it was reported that as some aspects of EB are controversial in society, by teaching EB, teachers can train students to accept different points of view regarding nature. Therefore, the structural aspect of this conception does not reside in facets of the evolutionary theory itself. Consistently, participants' concerns were the pedagogical aspects of teaching and learning EB. Within this conception, EB is a subject among others. However, it includes topics that can meet the resistance and the misconceptions of part of the population.

> *You have to teach within the Catholic teaching charter and that is obviously difficult when you are teaching a course. Children do ask you, they say 'but are we from monkeys?' and 'how does that work?', but I suppose that is the same as you teach reproduction and fertilisation.* (T13)

Therefore, the undemocratic exclusion of such part of the students' population is avoided through the use of constructivist pedagogies that could safeguard the multicultural sensitiveness.

The phenomenographic analysis of discerning between referential and structural aspects of conceptions was very useful in revealing an empirical knowledge from the data. That is, although the teachers expressed three different meanings of the link between EB and GCE, a dividing line among these meanings fell between "EB as a science for a better world" (including conception 1 and 2) and "EB as a school subject for a better person" (conception 3). Conception 1 included views such as "EB provides the evidence that genetically we are all the same and that we are all part of a global family”. Conception 2 included views such as “EB provides the knowledge for understanding and conserving the global environment”. On the other side, conception 3 included views such as “EB is a school subject that includes very controversial topics”. From this point of view, it can be an exemplar school subject for interdisciplinary projects, for individual in-depth study and for training students in democratic debates and multicultural sensitiveness.

5.4 Reported constrains perceived in the interplay between Evolutionary Biology and Global Citizenship Education

Most of the participants stated to recognise a role of EB in providing students with opportunities for exploring GC issues. In addition, they manifested three different ways of thinking and reporting about the link between EB and GCE consistent with the conceptions emerged from the analysis of the data in the light of the first research question. Most of the participants were quoted in more than one conception, as it results from figure 5.3, which is intended for the reader interested in making inferences on the individual subjects.

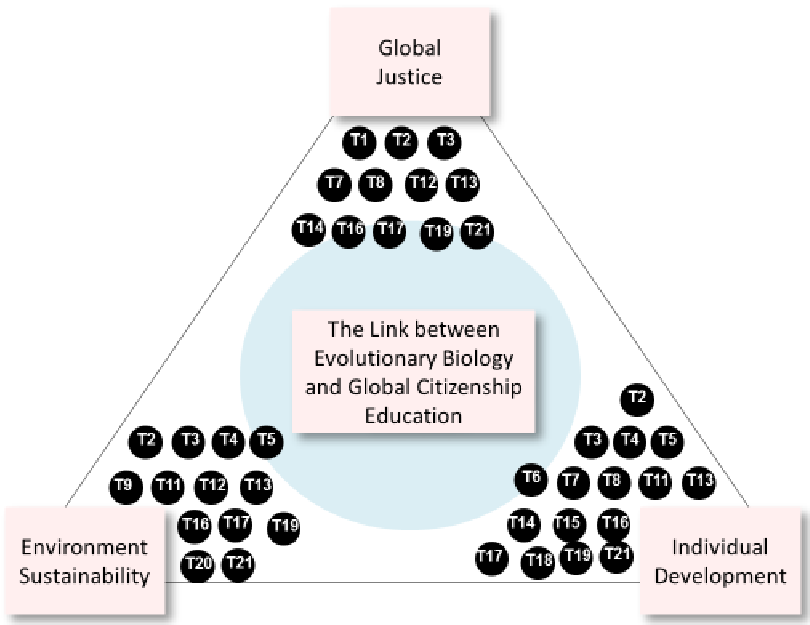

Figure 5.3 The triangle represents the interplay between EB and GCE and the each of the vertices one of the different categories of descriptions. Inside the triangle, the codes represent the quotes reported in the previous sections

Although a general consensus emerged on the possibility to link EB to GCE, constraints related to teaching EB with the purpose to educate for GC were reported by the participants. These obstacles included scepticism, SQA pressure, demands from parents, teachers' preparation, a demanding biology syllabus, lack of resources, lack of support from the senior management, the relationship with the students and the dynamics in the classroom. Table 5.10 summarises for each participant the main issue reported to constrain the teaching of EB.

	What are the issues of teaching about evolutionary biology with citizenship education purposes?
Teacher 01	Uncritical religious beliefs, but not a major issue in Scotland.
Teacher 02	Helping students to accommodate their possible uncritical religious beliefs with the scientific knowledge
Teacher 03	Not different that in any other classroom
Teacher 04	Cultural biases should have to be taken into account in the biology classrooms
Teacher 05	Cultural biases should have to be taken into account in the biology classrooms
Teacher 06	Early age of students make treating these themes ineffectual

Teacher 07	Early age of students
Teacher 08	Lack in the curriculum
Teacher 09	Strong opinions and beliefs
Teacher 10	Lack in the curriculum
Teacher 11	Keeping impartiality and people susceptibility
Teacher 12	Narrow minded people
Teacher 13	Lack in the curriculum, uncritical religious beliefs, sensible issues
Teacher 14	Time and syllabus
Teacher 15	Time and syllabus; Scepticism by part of the students
Teacher 16	Lack in the syllabus and teachers' lack of knowledge
Teacher 17	Lack in the curriculum
Teacher 18	Not different that in any other classroom

Teacher 19	Uncritical religious beliefs
Teacher 20	Lack in the syllabus, Early cognitive development of pupils.
Teacher 21	Lack in the syllabus. Religion interference and sensitivity of the issues might justify omissions.

Table 5.10 The main constraints related to teaching EB reported by each participant.

One of the participant clearly manifested a sceptical view. The following excerpt from his interview is a case in point.

R: What themes within evolutionary biology, in particular, do you think may have links with global citizenship?

T10: The evolutionary biology...?

R: Yeah.

T10: With global citizenship, I am struggling to see the link, the evolutionary biology and in global citizenship. If you are talking about natural selection, evolution, the whole idea as opposed to say creationism then we wouldn't be dealing with that. It's not, it's not an issue for debate as far as biologists are really concerned.

[…]

R: how does evolutionary biology is relevant in our understanding of our relationship with the rest of humanity?

T10: Again I am failing to see, it's just me but I am failing to see where there is either an issue in the first place or how it is going to help understand relationship with others especially the community. Unless you are really getting down to the ethnicity of people, and which case as Biologists you are just saying […] that we are all the same really apart from a few genes I don't think that's the big issue. I don't think that's the reason people, or I don't think that it is actually going to help solve world kind of, solve world peace.

One of the problems reported was the supposed lack of preparation of the teachers in this subject.

> *R: What do you perceive as constraints on using evolutionary biology?*
>
> *I think the main constraint is teacher knowledge. Biology is such a vast area, I also teach chemistry. Chemistry is very in some ways narrow whereas biology you have the environment, you have the human body, you have evolution and it is such a big topic in some ways that the depth is not there. So, you know a lot but you know it very shallow whereas I think to get a really good discussion you would need to more about it. And it is not an area that I particularly have studied a lot. I have done a lot more immunology and chemistry. I see that as a weakness in me so I think teacher knowledge of how to get a little bit deeper and to get really into the issues.* (T16)

Teacher 6 highlighted the fact that some of the biology issues are particularly complex and would require a higher level of cognitive development of the students.

> *R: What are the implications of genetics for our understanding of the relationship between human races and ethnic groups? In your view, are they relevant or not?*
>
> *T6: I think it is very relevant but it is such a difficult concept when you teach genetics there are two or three kids in the class that are like you or I going ahhh and the rest in the class are going I am not sure I get it and there are one or two that are just blank. […] there are a lot of kids of different ages and stages that simply will not understand. […] It is not easy to teach that and it is not easy to understand that even if it is taught really well. Even if it is taught by someone very experienced who has taught it lots of times in the past and who has got a really good grasp of it.*

The young age of the students and their early cognitive development were believed to be possible barriers in dealing with themes related to evolution, gender and race.

> *There is a certain level of maturity that needs to go along with that so that in first year when they are looking at people that are different to them and going mmm and giggling and just not having the cognitive ability yet to perceive people out with their own sphere and that is part of their own development. (T6)*

It was suggested that evolution is a topic of biology, among others.

> *That is tricky because I have not taught much evolutionary biology for a long time because I teach human biology which does not really have much about this in it.* (T21)
>
> *There are time constraints, you know, we have some time to study evolution but then it is straight on to another topic.* (T15)

In addition, evolution, rather than as an historical fact, was seen as a bioethical dilemma on which students can have contrasting ideas and can even reject.

> *If you were teaching to work your citizenship you would be making them aware that there are these other opinions and being that we are accepting of other people's opinions rather than you just going blast and saying this is the way it is, we evolve from apes. There are other opinions as well. There's the big bang. I mean, who would believe that? That's someone else's opinion. So, you have to make it aware of that.* (T7)
>
> *Evolution, again, it is an informed decision about whether or not they want to believe it or whether they don't want to believe it.* (T15)

A national curriculum for which part of the population completes the compulsory education without being exposed in school to the Darwinian theory was considered adequate.

> *I think when you teach it you want them to understand all the facts behind it rather than just teaching and saying this is what happens and then doing the mechanism of natural selection. […] First and second year the constraint is that it is not in the syllabus but also they are just not developed, they don't have enough background knowledge I think to do that, so I guess it is a constraint in a way.* (T20)

From such a point of view, omitting the study of evolution from school science is possible, unless the students showed a particular interest for biology.

> *I think if children have opted to select biology* […] *it is your role to give them the information whether they then chose to believe it or accept it then that is up to them. But I do think they should be taught that information because that is the current scientific thinking so that is what they should know, it shouldn't be censored or hidden from them.* (T13)

The main reported perceived constraint was the lack of time.

> *I think there is a whole gambit of things that you could develop within there, assuming that you have the time to build that into what you are teaching. (T14)*

However, a number of teachers maintained that evolutionary biology was underrepresented in the biology syllabus.

> *That is really only the opportunity that I currently use for evolutionary, we don't do evolutionary biology in first and second year* (T13)
>
> *Evolutionary biology in Scotland it has only just moved down to lower levels of teaching. So, natural selection previously was only taught in higher and intermediate it was not really taught in standard grade.* (T16)
>
> *Unfortunately, neither gender nor race is discussed in the curriculum. I totally think it should, so I discuss these things in the spare ten minutes or the first ten minutes of the lesson. Because I do think like I said before it is a very good way of putting race and gender and to put it into context for people to become better global citizens […] even evolution is far too short. They only get that in higher. They are now getting it in the nationals that is the new curriculum. (T17)*
>
> *I would think the main constraint is that it is such a small part, evolutionary biology is such a small part of what we teach and we would only teach it in the fifth year and it would only be a very small part of one unit.* (T21)
>
> *If they have not taken biology, they could just do up to second year and do science which includes biology but then they might take physics in which case they would never do evolutionary biology. (T20)*

It was also suggested that that the reason for such underrepresentation in the State secondary school curriculum was the power exercised by religion in the educational system of Scotland.

> *Maybe you have found that evolutionary biology is not something that is focussed on to any great extent and I am just thinking I wonder if that is because historically schools were from the Church in Scotland.* (T21)

Students religious beliefs and teachers' concerns with religious issues were another barrier reported for teaching evolutionary biology.

> *I think it is a very controversial area and I think it is fraught with problems, I don't think it is easy and I don't think all teachers feel comfortable teaching it because also they might have religious views that don't always sit one hundred percent with it. (T13)*
>
> *From me it would really just be in religious beliefs that cause tension sometimes. (T4)*
>
> *Constraints here would be to stick to the teachings of the Catholic Church, because if you were to say something that you shouldn't then you might have parents complaining. (T9)*
>
> *where there is a strong Catholic belief you are having to be sensitive to the idea that you are saying something is not true that they believe in. I think that is why certainly evolution of humans, you know that is not really explored at Higher biology it is more plants and animals and how they adapt to different environments.* (T13)

Only one of the teacher reported serious attempts to oppose his academic freedom.

> *I remember being in a school where the parents had expressly asked that the pupils learnt nothing about evolution and they were removed from the class, which I thought was poor because that was an opportunity missed for that person. […] That was about eight years ago, the pupil was a second year and we did a topic on evolution and the pupil's parents had written in and said they didn't want their child to learn about it.* (T2)
>
> *I even remember when I taught in another school in [area of Scotland] and it was a Catholic School. The Head of Biology said to be careful what I said about evolution, and I said I don't know what you're talking about and he really didn't want me to - and he said "Present the facts, don't answer any questions and then move on quickly".* (T2)

However, real constraints such as those described by teacher 2 were not reported to be a trend by the other participants in this research.

> *The presence of different cultures in the classroom makes the link with global citizenship easier. So actually, I don't find limitations or constrains in such situations, on the contrary there are lot of prompts, also because teenagers are quite curious. In the classroom, I have Muslim pupils; others are from Africa and East Europe, others from Far*

> *East. So, I really think that they are curious in a positive way, about the different physical aspects which is biology.* (T18)

> *We've got huge variety of race within our country of Scotland now and pupils are becoming much more aware of it.* […] *I think this is definitely going to form a big part of our talk in classrooms. Because pupils want to know this stuff, it's of interest, it's personal to them. It's also very good for breaking down racial barriers within your classroom.* (T11)

> *Then we have Muslim children and we have children who have fundamental Christian belief and it is quite interesting for them even within those faiths, generally I am just thinking of the past few years no child has said 'well no evolution is not for me'.* (T19)

> *You would find small pockets of people who didn't accept evolution, but as a whole you wouldn't have major issues. It's not a major issue in Scotland.* (T1)

> *I haven't actually encountered any major issues or tensions that have really put a stop to any lessons, I haven't ever had that situation.* (T3)

If not religion, the sectarianism affecting areas of Scotland was seen as an obstacle in teaching biology.

> *I think in some places where there are racist problems or even in some Glasgow schools where you have got the whole Rangers, Celtic thing going on there are barriers that are difficult to overcome, especially within the scope of teaching biology. (T12, p.5)*

In addition, prejudices and misconceptions were reported as barriers for learning about evolutionary biology.

> *They are prejudice I am afraid to say. They come with one view and they do not really want to try and look at the opposite side of it.* (T16, p.10)

> *A lot of it* [misconception] *comes from home; how you've been raised and it can be very difficult to try and separate in the kids' minds that genetics and choices are different things.* (T4, p.25)

> *However, trying to get that across to a pupil, whilst explaining that genetically they are still identical, is a very difficult concept because they can't understand why, if they are genetically the same, they end up different.* (T3)

> *Obviously, there are lots of other issues with evolutionary biology it is not just to do with race, there are medical and all sorts of other things but the racial thing springs to mind foremost.* (T12, p.4)

5.5 Outcome Spaces of the Categories of Descriptions

In phenomenography, the outcomes of the analysis result in a number of qualitative different meanings (i.e. conceptions) of a phenomenon (i.e. an aspect of reality). Such different meanings are called categories of description and consist in categories empirically interpreted by the researcher and, for this reason, have to be distinguished from the hypothetical experiences that they represent. Traditionally, the outcomes include also the structural relations among the different conceptions. This structural relation is called *outcome space* and relates logically the different conceptions to one another, typically in a hierarchically inclusive relationship (Åkerlind, 2012). Therefore, phenomenographers aim to reveal not simply a set of different conceptions, but a logically inclusive structure relating the different meanings.

As phenomenographic research aims to explore the range of conceptions within a sample group, as a group, not the range of meanings for each participant within the group, the outcome space has the purpose to provide a holistic picture of the collective way of conceiving a phenomenon by the participants. In addition, ideally it represents the full range of possible conceptions of the phenomenon, at that point in time, for the population represented by the sample group collectively (Åkerlind, 2012). Therefore, by constructing the outcome space, every excerpt and every conception is interpreted within the context of the group of transcripts. Hence, in this section, firstly I logically and hierarchically organise the attributes of each conception and, secondly, I relate in an outcome space the conceptions concerning the interplay between SB/EB and GCE that emerged in this group of participants.

With regard to the category of description *Global justice* that emerged from the analysis in the light of the first research question, the scientific literacy provided in the biology classroom was correlated to biology-related social inequalities (i.e. first attribute). The acknowledgement of our responsibility (i.e. second attribute) as inhabitants of the richest countries of the world in the exploitation of resources was a requisite for understanding the role played by biology and biotechnology in the systems of profit exploitation (i.e. third attribute). From such a point of view, GCE was reported to be promoted through fostering human empathy (i.e. fourth attribute).

Similarly, the attributes featuring the same conception were in a structural and hierarchical relation in relation to the second research question. During the analysis of the transcripts, I noticed that twelve participants, when they were asked to discuss the interplay between EB and GCE, mentioned more than once the genetic equality of humanity. For this reason, I grouped all the excerpts of the transcripts that were expressing this thought in the same attribute that I coded "negligibility of biological differences" (see table below and 5.6).

First coding (mostly segments of the transcripts)	Attribute
we are all the same (t1, t2, t5, t8, t10, t12, t13, t14, t16, t19, t21)	Negligibleness of biological differences
we are not much different from everyone else (t7)	
there isn't really any biological differences (t2)	
we are all equal (t16)	
slight differences (t2)	
difference between people miniscule (t17)	
artificially kind of differences between people (t17)	
what we perceive as differences are cultural (t17)	
we all have the same genetics (t3)	
negligibleness of genetic differences (t3, t14, t17, t21)	
subtle differences in the genetic code between races (t7, t8, t12, t19)	
only few genes differentiating races (t10)	
minimal number of genes differentiating outward appearance (t10)	
just few differences in the base code (t13)	
slightly differences in protein (t13)	

awareness of negligibleness of the biological differences (t13)	
negligibleness of biological differences among ethnicities (t3, t12)	
evolution education reduce the gap between different ethnicities (t16)	
subtle differences in the genetic code of ethnic group (t12)	
negligibleness of biological differences among races (t5)	
differences reducible to pigmentation (t8, t13, t14, t15, t21)	
races as adaptation to sunlight (t13, t20)	
limited number of biological differences (t6)	
geographical adaptations (t10, t12, t13, t19)	

Table 5.11 The table lists, on the left, the first coding of the excerpts that were finally coded in the attribute *Negligibleness of biological differences* of the conception EB for Global Justice

The scientific knowledge (e.g. Human Genome Project) was linked to concepts of human equality/inequality. In the light of the first research question, the participants expressing this way of thinking linked science to the differential access to biological resources, such as water and medication. In a similar way, in the light of the second research question, participants linked science to the thorny issue of human classification.

In addition, during the analysis I noticed that eleven participants mentioned (globally twenty-eight times) that evolution was making real the connection among people around the world (see table below). Therefore, I clustered such twenty-eight excerpts in an attribute that I have labelled “connecting everybody”.

Initial coding	**Final coding**
giving context for global citizenship education (t20)	
evolution as evidence that we are all connected (t1)	

evolution education links all human beings (t19)	Connecting everybody
the core factor is that we are all related (t2, t17, t20)	
kinship with everybody in the world (t12)	
linking allele flow to human diaspora (t19)	
making Scottish students acknowledge that they share relationships with people living in other countries (t20)	
making a bit more personal the link we have with people living at the opposite side of the world (t16)	
great-great grandfather in common between teachers and students (t16)	
cementing the relationship with the rest of humanity (t16)	
evolution connecting people (t1)	
making commonality (t2)	
commonality with everybody in the world (t7, t12, t13)	
it is everybody together (t2)	
evolution education is building bridge between different population (t16)	
common place origin (t7, t13, t14, t16, t19)	
human common ancestor (t12, t13, t14, t21)	

Table 5.12 This table lists, on the left, the first coding of the excerpts that were finally coded in the attribute *Connecting everybody* of the conception EB for Global Justice

As the biological human equality was the consequence and the key scientific evidence of the recent common origin of humanity, the first attribute was a prerequisite of the second. In addition, both attributes were crucial, for debating issues of racism, sexism and population migrations (see table below and table 5.6).

understanding differences for promoting empathy (t13)	
pigs and cows are closely related to us: their suffering is like our suffering (t17)	

<table>
<tr><td>making students to remove barrier (t16, t19)</td><td rowspan="14">Promoting a non-hierarchical view of nature and empathy for other living beings</td></tr>
<tr><td>making students to realise that even people living very differently are the same as you (t16)</td></tr>
<tr><td>ridding of sense of diversity (t12, t14)</td></tr>
<tr><td>helping students is seeing others not very different from them (t14)</td></tr>
<tr><td>the natural common ancestor makes you a global citizen rather than a Scottish citizen (t16)</td></tr>
<tr><td>ridding of negative views on others (t14)</td></tr>
<tr><td>understanding science for promoting empathy (t13)</td></tr>
<tr><td>critique to the contemporary migration politics (t14)</td></tr>
<tr><td>as we are all genetically related why certain people should be not allowed to migrate in the UK and other people not? (t19)</td></tr>
<tr><td>linking with global human rights (t16)</td></tr>
<tr><td>evolution education arises the debate about citizens’ rights independently of their biology (t16)</td></tr>
<tr><td>promoting vegetarianism (t17)</td></tr>
<tr><td>animal welfare (t17)</td></tr>
<tr><td>non-human citizenry (t21)</td></tr>
</table>

Table 5.13 This table lists, on the left, the first coding of the excerpts that were finally coded in different attributes *Promoting a non-hierarchical view of nature and empathy for other living beings* of the conception EB for Global Justice

As for the outcomes of the analysis of the first research question, this conception seemed to show that the ultimate purpose is to foster, by using scientific arguments, the political dimension of students, in the attempt to promote empathy that include also non-human animals. Therefore, the stated intent to promote connectedness of living organisms is the most inclusive attribute of this way of conceiving GCE through school EB.

Within the second category of description identified in my study, the conception labelled *Environment sustainability*, in relation to the first research question, the understanding of the global impact of human activities seemed to be a necessary requisite to understand the damaging impact of human activities on biodiversity and, consequently, the call for sustainability in science education. That was to link topics of SB with environmental and global economy issues, with the ultimate aim to promote responsibility in the stewardship of a shared planet.

The analysis in the light of the second research question provided a very similar inclusive and hierarchical outcome space of the attributes constituting the conception. In fact, EB was viewed by the participants as providing students with the scientific literacy for understanding the danger posed by human activities on the present ecosystems, interpreted as fragile equilibria of complex evolutionary processes, and thereby for understanding how to conserve the present environment for future generations.

The third category of description, the conception *Individual Development*, was also structured in hierarchical attributes. The attribute I labelled *Work and responsibility in the community* was the less inclusive and the less global, when it is related to the purpose of citizenship education. In fact, within this way of thinking, school biology was presented by the participants substantially as providing the scientific literacy necessary for the young citizens to possibly undertake biology-related jobs, to behave in a healthy way and to be responsible for the health of the community in which they live. In other words, there was no mention to any real or hypothetical global community. The set of this way of thinking was the individual and the local and national communities in which the individual lives. It was also about becoming part of this (local) community, rather than changing or improving it.

In conceiving the phenomenon studied, the second attribute (i.e. *Democratic skills and impartialness of the teacher*) of this category of description seemed to be a necessary condition for the third. Therefore, the third attribute, *Understanding socioscientific issues*, is more comprehensive. In fact, in order to actively participate in the contemporary debates on the SSI, besides the scientific literacy young citizens have to learn the democratic skills of relating with other people in responsible, respectful and democratic ways. In addition, learning about other people's ideas is not simply being able to listen them in a democratic way. Learning other people's ideas is more related to the acquisition of these different ideas in one's own system of interpreting the world and then changing it.

Within this framework, biological literacy was viewed as a step toward promoting the wellbeing of the individual, both as a body and as a component of a local community. The democratic skills were a requisite for the realisation of a democratic debate in the local community of the biology classroom, also guaranteed by the impartialness of the biology teacher. The acquisition of a different way of thinking about the socioscientific debates occurring in the contemporary societies and the understanding of the universal language of science was a further step in the process of appreciating the collaborative and multicultural achievement of modern biology. Therefore, the attribute *multiculturalism* seems to be the most comprehensive of this category of description.

In the imaginary line representing CE that goes from local to global, the attributes of the category of conception Individual Development might be positioned in the following way.

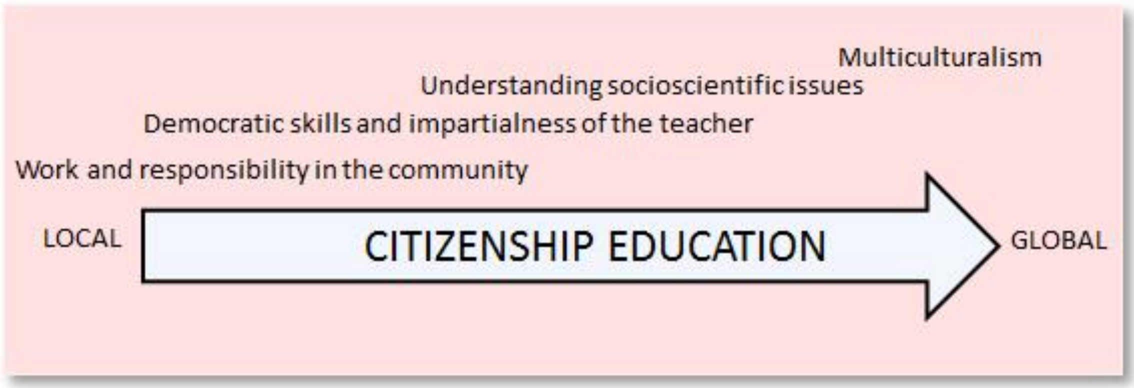

Figure 5.4 The imaginary line of CE, from local to global

In addition, the findings of the analysis reported in section 5.2.4 and summarised in table 5.5 show that the referential aspects of the three conceptions differ and are, in a way, complementary. In fact, while the overall meaning of the first conception resided in the implicit educational purpose to develop the political conscience of citizens, that of the second conception was the stated purpose to develop their ecological conscience and that of the third was to develop the cognitive, democratic and ethical dimensions of students. However, although complementary, the first and the second conceptions (i.e. Global Justice and Environment Sustainability) can be considered included in the sub-category of description *Understanding the Socioscientific Issues*. It seems quite clear, in fact, that the arguments of the participants classified in those conceptions are substantially socio-scientific issues themselves. The former is more related to social issues, the latter more to environmental issues.

The emerging narrative of the first conception is: the humanity is homogeneous, from a biological point of view, and genetically related with all the other living beings of this planet. The second conception narrative is: the global ecosystem is a very fragile product of evolution and is seriously jeopardised by human activities. Therefore, both conceptions are indispensable prerequisites for understanding the socioscientific issues and for promoting responsibility in the global community. However, the understanding of the socioscientific issues is a feature and an attribute of the third category of description which is in the outcome space the most inclusive category representing the interplay between SB/EB and GCE. The following diagram is the comprehensive outcome space of this study and it visualises the complexity of the interaction between SB/EB and GCE.

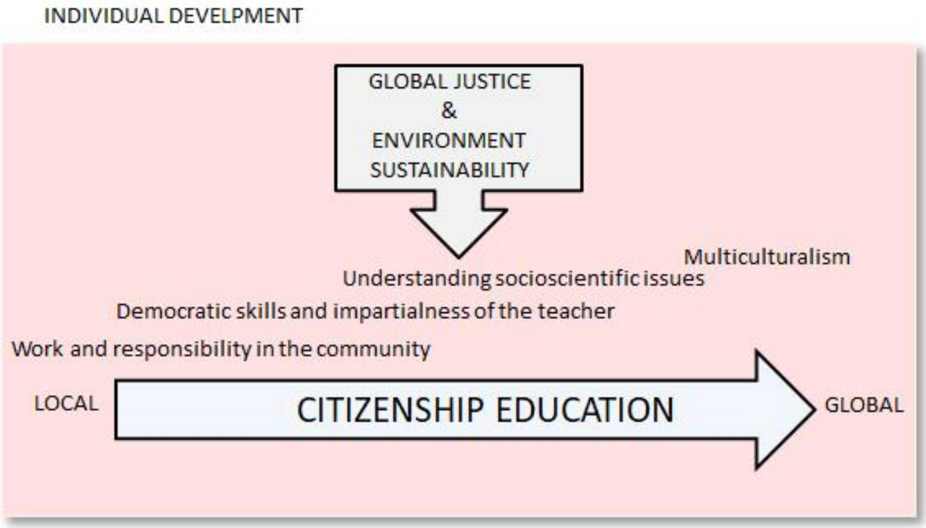

Figure 5.5 Outcome space of the phenomenographic analysis of this study

This outcome space represents the full range of possible ways of understanding the link between SB/EB and GCE in the group of participants interviewed in this study. The three concepts emerged from the biology teachers' understanding of the link between SB/EB and GCE seem to be intertwined variations highlighting different aspects of the same phenomenon. The *Individual Development* category seems to be the most inclusive in educating students to cosmopolitan values, while the declared aims of the conceptions *Global Justice* and *Environmental Sustainability* can be considered essential and complementary components of the scientific literacy requested from citizens of contemporary societies.

In conclusion, this empirical study explored, through a phenomenographic analysis, firstly the biology teachers' views on GCE and secondly their interpretations of teaching SB/EB in order to educate for GC. The data show patterns in the participants' arguments. These patterns allow to organise quotes from the transcripts in different groups of coherent attributes. The same three different coherent groups of arguments emerged from exploring the two main research questions. These three different coherent groups are three different conceptions and can be seen as a map of the collective mind of the secondary school biology teachers who participated in this study.

Chapter six Discussion

6.1 Chapter Overview

The aim of this discussion is to collate the findings of the literature review, the document analysis and of the phenomenographic study in such a way as to gain a holistic understanding of the extent to which school EB can contribute to GCE in secondary school. With this purpose in mind, I discuss the insights gained from the empirical study and I illustrate the challenges and the opportunities that teaching EB offers for the purpose of CE, in the context of compulsory secondary school CfE.

In the following sections, I first summarise the findings of this study and then I provide the reader with my interpretation of the main results, in consideration of previous research. In Section 6.3, I interpret the findings in the light of the role of SB in secondary school CE. In Section 6.4, I discuss my view on the significance of the results in the light of those aspects of EB that either monopolise the discourse of CE or are omitted by the compulsory secondary school science education. I show that the interplay between SB and CE, the exclusion of fundamental tenets of EB and the discourses of EB monopolising the compulsory secondary school education synergise to provide a civic education, rather than a GCE inspired to cosmopolitan values. I conclude this chapter, by critically evaluating my work, highlighting not only problems and limitations, but also its implications, making suggestions for improvements and directions for future research.

6.2 Summary of the main research findings

I started this study as a secondary school biology teacher with the purpose to explore to what extent EB can contribute to GCE in secondary school. With this aim in mind, I explored three literature fields in order to understand the state of the educational research firstly in relation GCE, secondly in relation to the link between SB and CE and finally in relation to teaching and learning EB. As my study was carried out in Scotland during the implementation of an ambitious curricular reform that emphasises the role of school in CE, I conducted an empirical study exploring the challenges and the opportunities for teaching biology and in particular EB for the goal of CE. In my study I have analysed the biology curriculum context within the CfE, the textbooks for compulsory secondary biology education in Scotland and the conceptions of the biology teachers.

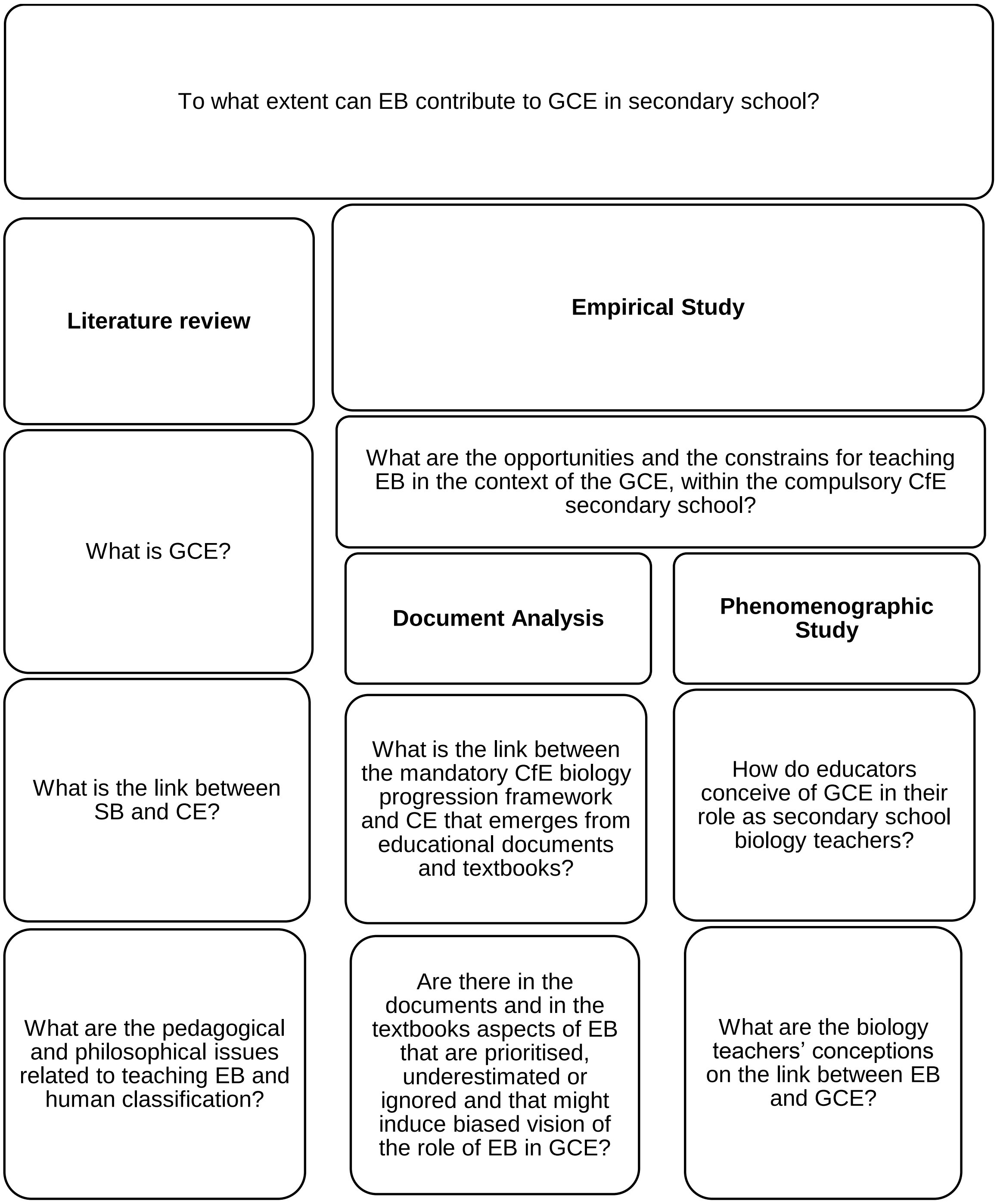

Figure 6.1 Summary of the research questions

My purpose was to gain insights into the relationship between teaching EB and GCE. Figure 6.1 summarises the main research questions, under the overarching question of my study.

The tradition to educate citizens through school biology in the UK has its roots in the 1930s, when biology was included in school curricula in order to deal with issues of public health, nutritional standards, race and nation, among other social problems (Jenkins, 1979). Nowadays, biology literacy is an international educational slogan, with the declared purpose to prepare students for active, democratic and informed participation in society. This is related to the anxieties generated by genetic manipulation, the use of embryos in stem cell research and other biotechnologies that interfere with people's values and result in high uncertainties and in increasing tensions between scientists and non-experts. That is when the SSI movement originates in science education. Therefore, biology teachers nowadays are requested to address in their classrooms some of the complex scientific issues that interact with students' values and are objects of controversy in society, by using active learning pedagogies and NOS learning context.

Among the different frameworks of school science developed to promote the democratic participation of students, the so-called *science education for conflict and dissent* framework is particularly relevant for this thesis as it relates to the concept of *biological citizens* (Rose and Novas, 2004). This underpins the idea of belonging to a group of people because of a shared biological feature. The construction of biological citizens may have either the positive valence to empower a suffering group of people or the negative power of discrimination (Rose, 2007). The social constructions of biological citizens and identities sometimes result in the biologising of race, gender, ethnicity and nationality, which consists of the attempt to biologise culture and ideology (Rose and Novas, 2004).

Appiah (1985) maintains that the construction of racial biological citizens underpins the belief that differences in morphology are correlated with intellectual capacity.

Analysis of the Educational Documents

- The aim to promote values of justice and compassion and an understanding of diverse cultures evokes principles of cosmopolitan education
- Teachers are demanded to interpret in creative and innovative ways the biology specifications so as to guarantee flexibility for schools and national standards
- Sometimes the SQA exemplifications suggest an unquestioning confidence in the application of science. For instance, it is stated that the use of chemicals in agriculture has the purpose to feed the increasing human population
- The CfE texts illustrating the expected outcomes are open texts, according to Eco’s taxonomy. This means that the texts are incomplete and thereby they need to be completed by the cooperation of teachers with their expertise. Therefore, biology teachers are free to interpret, for instance, the use of chemicals in agriculture in a critical way, opening debates and discussions in the classroom
- In relation to EB, the SQA suggested activities focus on the applications that position humanity at the centre as they are supposed to provide some sort of economic-medical-legal benefits to humanity. For instance, SQA Support Notes suggest to explore in the classrooms the topic of golden rice, less toxic rape seed oil, bird resistance to bird flu, tomatoes with longer shelf life, blight resistance potatoes, production of medicines for human use such as insulin and growth hormone
- Natural human history is completely disregarded in the CfE biology specifications for the S1-S4 age range. In the same way, the contribution of EB in the understanding of human taxonomy is ignored. The analysis of genome sequences to compare the degree of kinship between humans and other living beings is not suggested. Similarly, the use of DNA sequence analysis for intraspecific comparative studies is not suggested.
- The compulsory biology specifications do not formally introduce the students to tree/phylogenetic thinking
- Natural selection, adaptation, competition, cloning, applications in agriculture and medicine are key words in the vision of EB emerging from the mandatory areas of the CfE biology progression framework. Evolution, human evolution, phylogenetic trees, trees of life, cladograms, tree diagram, tree thinking and population thinking are all concepts that are neither explored nor explicitly stated
- The texts illustrating the EB CfE specifications are open texts. Therefore, teachers, with their knowledge, interests and creativity, can complete the “unsaid” text with alternative vision of EB

Figure 6.2 Summary of the findings of the analysis of the educational documents

The timeless attempts to biologise genders, Apartheid and Nazi Germany are only three of hundreds of possible negative instances of the construction of biological citizenship based on the attempt to make a link between simple biological characteristics and complex individual features such as intellectual or moral capacities.

I argue that the social construction of biological citizens is in contrast with the aim of GCE to promote cosmopolitan values and the idea of a humanity belonging to a single global community. In fact, central to this interpretation of GCE is the promotion of the ability suggested by Nussbaum (2003) to think what it would be like to be in the position of someone else and the feeling of compassion beyond the line of time, race, gender and place. For this reason, Nussbaum suggests that in order to cultivate compassion in schools, we have first to discourage our tendency to divide the world into us and them. Therefore, to make compassion real, we have to make the others somehow familiar. Compassion, she argues, allows us to go beyond the anthropocentric notion that lies in the human-animal dichotomy and, thereby, it allows the inclusion in “us” also of the non-human animals.

The biologisation of complex features of individuals also risks promoting gross mistakes in biology. The construction of biological citizens based on the pigmentation of their skin is a case in point. On the basis of the distinction between white and non-white we might be induced to think that the biological differences between two people with different skin pigmentation are greater that those between two people with the same pigmentation. This belief is untenable from a biological point of view.

EB has been sometimes called upon to support the stigmatisation of the biological identities of citizens. For instance, the larger size of Caucasoid brains has been an unquestioned scientific fact until quite recently (Gould, 1996). The emeritus American palaeontologist Stephen Gould (1996) reports that when he was a child, the Hall of Man in the American Museum of Natural History displayed the racial variability of human features with a linear series running from apes to white people through the intermediate position for blacks. In addition to the attempts to justify racism with EB, Darwin is often associated with social Darwinism, although the father of the so-called Social Darwinism was actually Herbert Spencer (Ruse, 2005). Significantly, Darwin is not known for his commitment to the abolition of slavery (Desmond and Moore, 2010). In the literature review, I illustrated that educational research widely documents other misunderstandings and misconceptions related to EB, in particular related to the issues of human variation and human evolution (Gregory, 2009).

Analysis of the Textbooks

- The textbook narrative of evolution is “adaptation for survival”, rather than “common ancestors”
- Evolutionary information is segregated in isolated sections
- EB consists of an isolated content organisation, rather than being the unifying theoretical organiser
- A clear feature of the biology textbooks is the absence of phylogenetic trees and cladograms. In the six analysed books there is only one phylogenetic diagram
- The common descent theory is very poorly represented
- Our species is not represented in any phylogenetic trees and there is no mention of the common ancestor for all living beings of our planet. As a matter of fact, the natural history of our species is ignored. Our species is only mentioned in relation to negative mutations
- There is no attempt to develop population thinking. In fact, there is no mention of the genetic homogeneity of humanity as a consequence of the recent common origin. Human height, rather than skin pigmentation, is used as an example when treating the topic of “Continuous variation”.
- None of the analysed textbooks explicitly connect the origin of biodiversity with the Darwinian theory of multiplication of species

Figure 6.3 Summary of the findings of the analysis of the textbooks

With this thesis, I argue for the opposite idea that in the attempt to promote a sense of belonging to a single global human community and the Earth as a whole, EB with the revolutionary theory of brotherhood of animals, plants and people

(Desmond and Moore, 2010) may have a role. However, among the pedagogical and philosophical issues related to teaching EB, I would argue that the popular acceptance of typological thinking for the classification of living beings may represent a serious constraint.

Analysis of the Interviews

- Most of the teachers acknowledge a significant role for biology education and EB in educating for GC
- From the phenomenographic analysis of the transcripts, three different ways of conceiving the education for GC through school biology/EB emerge. These were labelled in the following way: *Global Justice*; *Environment Sustainability*; and *Individual Development*
- *Global Justice*: GCE is linked to SB by using arguments for the demand of social justice. For instance, the topic of vaccines is related to the unequal access to vaccines in the world, rather than to epidemiology or citizens' scientific literacy. In addition, the teaching of the Common Ancestor theory and the biological homogeneity of our species are viewed as a means to develop a common sense of belonging to humanity. EB is also a tool for challenging students' anthropocentrism and for possibly promoting a non-hierarchical view of nature and empathy for other living beings
- *Environmental Sustainability*: ecological issues and environmental education are linked to the Scottish biology curriculum. Educational purpose is to develop, through biology, the students' ecological conscience. In addition, EB is fundamental for understanding events in the history of the Earth and the mechanisms that generate and maintain the biodiversity of our planet
- *Individual Development*: the main concern is the democratic, cognitive and ethical development of the students, by promoting healthy lifestyles, responsible behaviour, democratic participation and multicultural sensitiveness. Understanding of EB is viewed as a pedagogical device for challenging students' beliefs and promoting Nature of Science and SSI education
- Teachers acknowledge that EB may promote GCE as the notion that we are all related might provide a sort of real context for the construction of a global human community. In addition, most teachers, when asked to discuss the interplay between EB and GCE, mention the genetic and biological homogeneity of humanity

Figure 6.4 Summary of the findings of the phenomenographic study

This classification consists, substantially, in ascribing to individuals a typical feature, a supposed peculiar essence, characterising the different species, races, ethnicities, populations, genders and so forth. In opposition, EB contrasts such an Essentialist position with the Population Thinking, by considering any typical features a little more than statistical abstraction. From such a Darwinian point of view, the typological thinking is a serious constraint for understanding biology because it may lead to considering certain categories as real, natural and information-rich, rather than human constructions (Gelman and Rhodes, 2012). In contrast, Darwinian classification does not consist in discerning the essence of a given species or group of individuals. Rather, it is based on the understanding of phylogenesis, that is shared ancestry, and on the construction of phylogenetic trees (Baum and Offner, 2008).

This is, in short, the educational picture in which I have conducted my empirical study, the main results of which are summarised in the diagrams reported in Figures 6.2, 6.3 and 6.4.

In summary, both SQA and textbooks highlight a vision of evolution characterised by key concepts such as microevolution, adaptation, mutation, agriculture and biotechnologies improving the life of people. Natural history, macroevolution, human evolution, common ancestry, population thinking and phylogenetic trees and even the name of Darwin are words and concepts that are not explored. However, the texts of the CfE illustrating the biology specifications are open texts. This means that they are incomplete texts that need to be completed by the expertise and the creativity of the biology teachers. In other words, the biology specification contained in the CfE cannot be considered a constraint for interpreting EB differently, for example, from the view emerging from the non-mandatory SQA suggestions and from the textbooks. In fact, most of the teachers who participated in my study mentioned the genetic and biological unity of humanity, as an instance for promoting GCE. In addition, a number of the participants mentioned the theory of common ancestry as a possible framework for developing a sense of belonging to a global human community.

6.3 School Biology as a Natural Vehicle for delivering different conceptions of Global Citizenship Education

Traditionally, citizenship education has been linked explicitly to human studies such as history, religion, geography, economics, politics and sociology. For instance, a piece of research framed in the International Review of Curriculum and Assessment Frameworks Archive (Kerr, 1999) that analysed how CE was addressed in 16 countries (which included England), revealed that, in the secondary school curricula of most countries, CE was mainly organised through an integrated approach, but often as a discrete, explicit component alongside subjects such as history and geography. The study also revealed that, in many countries, the range of subjects that were related to CE was extended, in the upper years, to economics, law, commerce and political sciences. In addition, the research illustrated that moral education continued to be an important component in some countries, in particularly those in Southeast Asia. The same study highlighted that in most countries there was no specific initial and in-service training of teachers for CE and that most teachers were trained in "closely related subject areas, notably history, geography and social sciences" (Kerr, 1999: p.20).

Moreover, Kerr's study (1999) reported a sort of inadequacy in the preparation of the teachers in many countries. Such an inadequacy was related not only to a lack of content knowledge but also to the teachers' inability to employ a range of teaching and learning approaches appropriate for CE. In contrast, in the present study, the participants did not manifest any feeling of inadequacy in their role of citizenship educator as biology teachers. This finding could be the result of the bias of the sample. As already mentioned, the sample consisted of biology teachers who had voluntarily accepted to be interviewed about GCE. This interpretation is supported by research showing that many science teachers agree with proposals to contribute to CE (Michener and Anderson, 1989; Lumpe et al. 1998; Sadler et al., 2006).

At present, in Europe, science teachers deal with CE by involving students in discussions, debates and critical thinking about controversial socioscientific issues. As I have already illustrated, when science teachers are asked to deal with controversial issues in CE, they respond in three substantially different ways. Some teachers explicitly resist the idea of dealing with issues related to students' values and beliefs in the science classroom, arguing for a value-free science education. A second group states that they are in theory committed to such an educational proposition but prevented from its actualisation by constraints, in particular lack of time and preparations for exams. Science teachers from a third group maintain to be committed with respect to teaching SSI and consider themselves citizenship educators as well as science teachers.

Most of the participants of my study were motivated in CE and most likely they all belong to the third of the abovementioned categories. However, another factor should be considered. In the "age of genomic medicine" (Rose, 2007: p.155), biology has become a key element of citizenship and the demands of citizenship in a global age require the development of competencies that had not been traditionally emphasized by CE. As a result, since the early 1990's, social scientists, across a number of different disciplines, have manifested an interest in biology, particularly after the Human Genome Project (Raman and Tutton, 2010).

The central role of school biology in GCE clearly emerged from the data collected with my research. As I have illustrated, most of the participants acknowledged that school biology seems to be a natural vehicle for delivering GCE. For instance, most of the participants argued for the need to make students aware that citizens are biological systems integrated in a very complex web of interrelated ecosystems and that the biology issues are global in themselves and impact on people's everyday lives. In addition, they also argued that EB with phylogeny, through teaching that we are all related, can provide students with a sort of a real context for creating a global community. Therefore, even among the other sciences, biology was considered by the biology teachers the best subject for dealing with citizenship.

The findings of this study are in accordance with a study conducted by Cross and Price in Scotland and in the United States (1996). That study explored the conceptions of the science teachers regarding the tension between traditional value-free science curricula and the teaching of controversial issues. The researchers argued that, with respect to the teachers' acknowledgement that schooling of science should enable students to recognise the complex interrelationship between science and society, and concluded that the results of the study were therefore "encouraging" (Cross and Price, 1996: p.330).

My study has revealed a commitment among the participants to place a decisive role in SB, in providing students with the instruments for interpreting the complexity of the interrelationship among biology, biotechnology, the global economy and global society. However, their underlying beliefs differed. In fact, as was shown in the previous chapter, by analysing the interviews in the light of the biology teachers' stated reasons for embracing GCE, the data could be clustered in the three identity profiles. These could be labelled with their overarching meaning, namely: social justice, environment sustainability and individual development. However, the data showed that the features of each spectrum of ideas were intertwined with others, rather than making competing conceptions.

In the first of these three possible ways of thinking about educating for GC, Social Justice, the critique of the notion of biology as a neutral science operating in the interests of the whole of humanity was clearly implicit. In this category, biology was presented by the participants as part of the systems of profit that contribute to the inequalities in the world. In fact, the interviewees claimed to have raised, in their biology classroom, the issue that in the world there are inequalities related to biology. The inequalities considered were the unequal access to clear water, the unequal access to vaccines, the economic interests of industry who developed anti-cancer treatments and those of first world drug companies "charging too much" the people who are suffering from

AIDS or malaria. In addition, participants argued for the need to understand genetics in order to disclose the fact that “there are problems that affect ethnic groups that we have not” (T3) does not mean that “we” *could* not.

Advocates of this social justice framework maintained that their own contribution to GCE consisted, substantially, in the attempt to develop in students the awareness that there were consequences of their actions on other people in the world. In their words it was implicit that the acknowledgment of one’s responsibilities could raise in the students a sense of agency and could promote socially responsible actions. In addition, they believed that their explicit contribution to GCE was in their attempts to make students aware of the commonalities among different people in the world, to communicate the idea of a single global human community and to promote empathy for people living in other parts of the world.

This first perspective to have emerged in my research overlaps with the visions identified in an empirical research conducted by Westheimer and Kahne (2004). These researchers asked what kind of citizens support an effective democratic society in an educational program in the United States. Their findings indicate that the way educators design and develop their programs influences the ways in which students understand the ways they had to act as citizens. In their study they labelled one of the visions with the terms *justice oriented* because it was characterised by the rhetoric of the importance of pursuing social justice. Similarly, in my research, some teachers seemed to prioritise in CE the purpose to develop the students’ ability to critically assess the social, political and economic structures underlying the social reality.

This social justice view that links science education to political discourses seems to be related to radical scholars who place emphasis on the need for social critique and change (Freire, 2007). Rather than organizing the food drive and donating food, justice-oriented citizens are those who ask “why people are hungry and act on what they discover” (Westheimer and Kahne, 2004: p.242).

Within the justice-oriented citizen perspective, the good citizen is seen to assess social, political and economic structure in a critical way and to challenge the status quo of systems. Similarly, the participants in my study that were associated with the Global Justice identity wished to engage their students in the understanding of how biology, as a component of a global system of profit, is part of the issue of global injustice, rather than in understanding how biotechnology can serve humanity in order to solve such a problem.

The other two perspectives emerging from my study were more related to those views that emphasise that problems in society are caused by personal deficits. In fact, the discourse running throughout the words I labelled Environmental Sustainability and Individual Development seemed to be illustrated by the pedagogical aim of developing the ecological, democratic and ethical dimensions of the students. From this point of view, a good citizen is one who acts honestly and responsibly in society and possibly who actively participates in community organisations, in the public debate and in decision making. From this point of view, health science, for instance, was considered a component of the individual development of pupils by helping students to reach a mental, emotional and physical equilibrium. Therefore, while some participants focused on social health and international health areas, others focused on how to develop an understanding of the factors which contribute to a healthy lifestyle and to an individual psychological and physical fitness.

The environmental sustainability approach identified in my work can be related to what Westheimer and Kahne (2004) call the participatory citizen, who is someone that actively participates in the local and global society. In fact, by highlighting in the biology classrooms the global impact of human activities on the environment, these teachers’ stated contribution to GCE consisted in the attempt to develop ecological awareness in order to promote behaviours resulting in the promotion of environment conservation and in the idea of a shared stewardship of the planet.

Finally, the third identity can be linked to the citizen that Westheimer and Kahne (2004) define the ‘personally responsible citizen’, who is someone who acts responsibly in his or her local community. Within this third perspective biology, no more than any other subject, and in relation with the other subjects of the curriculum, can provide the students with the tools they require to live in their social reality. Therefore, biology educators can contribute to preparing the students for their future jobs; facilitating their integration in the local communities; promoting their ability to express opinions and to listen to those of others; making scientifically informed their choices; stimulating their participation in the socio-scientific debates; promoting collaboration through the universal language of science; and appreciating the multicultural modern western society.

The document analysis revealed that the different conceptions of the teachers I interviewed are legitimated by the CfE biology specifications. As I mentioned previously, the texts illustrating the specification are open and thereby they allow the teachers to interpret them and complete them with their creativity and competence. Therefore, the participants that stressed the emancipatory power of the scientific literacy as well as the participant who considered health science a necessary step in the individual development of students could find validation in the following excerpt of the CfE: “in this Unit, learners develop an understanding of factors which contribute to a healthy lifestyle, through a personal, community-based and global approach. Learners cover procedures to measure physical fitness, investigate mental/social health issues and research media reports of national/international health areas” (SQA, 2013g: p.7).

This finding of my document analysis finds a correlation in Barrue and Albe’s (2013) investigation of CE in the science curriculum of French Middle Schools. Barrue and Albe claim that, on one side, the French curriculum aims at building virtuous citizens able to live with others. On the other side, the purpose is to build critical citizens able to debate and express choice.

With the analysis of the data I revealed in the previous chapter showed that these different pedagogical approaches to educating for GC in the biology classroom are not competing and are intertwined, at least in the mind of many of the participants. However, looking at the data, in the light of what kind of individual responsibility should be promoted, a polarised tension seems to emerge between the Global Justice identity, from one side, and the other two identified identities, on the other. This tension seems to reflect the antagonism between educators who place the emphasis on the analysis of the causes of social problems and those who place the emphasis on individual behaviour. Barrue and Albe (2013), in a similar way, relate what they call emancipatory citizenship to a form of CE more connected to the promotion of critical thinking, while they relate so-called 'normative citizenship' to a form of citizenship education inspired by rules and civility ascribable to the idea of virtuous citizen.

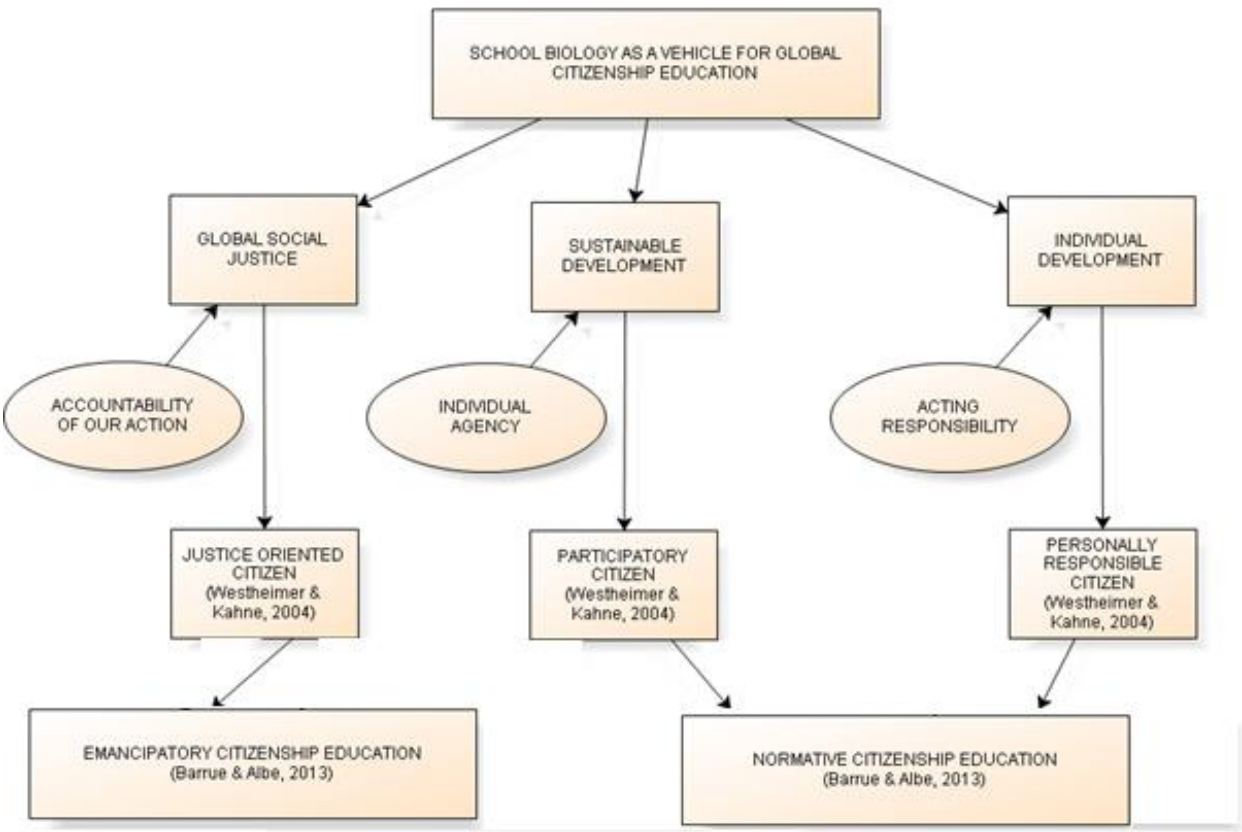

Figure 6.5 Relation between findings and literature

The idea of the virtuous citizen is also reflected by the words clustered in the categories of description that I labelled Individual Development and Environment

Conservation. A clear feature of this way of understanding GCE was, in fact, the openly stated effort to foster personal responsibility. Explicit purposes of this kind of GCE were, for instance, to educate the students to look after themselves and their environment (teacher 3); to provide the scientific information necessary for making responsible choices in terms of health and environmental conservation (teacher 4); to emphasise the responsibility they have for the planet and the impact of their actions on the entire world (teacher 5); to foster awareness that the resources of the world are limited (teacher 6); to inform students that their actions may have both a positive and negative impact on the planet (teacher 6); to make students aware that our actions can have a domino effect on all the ecosystems in the world (teacher 6); to care about the global environment (teacher 10); to facilitate students' integration into their own community, leading them forward into the workplace and promoting responsible individual behaviour (teacher 11); and to inform them about sustainability and food security (teacher 13).

Critical observers of this kind of CE consider these purposes all desirable features of citizens. However, they argue that the emphasis of individual responsibility can distract attention from "ways that government policies can advance or hinder solutions to social problems" (Westheimer and Kahne, 2004: p.244).

In conclusion, Figure 6.5 constitutes an attempt to graphically relate the findings of my research with other findings reported by in the educational literature. A further purpose is to highlight the polarity between the emancipatory CE identified in the literature and revealed by the Social Justice identity of my study, from one hand, and, from the other, the normative CE, revealed by literature and identifiable both in the Environmental Sustainability and in the Individual Development identities of my research.

6.4 Missing the Importance of Deep of Time, Phylogeny and Population Thinking to Society

The main finding of my document analysis is that the biology curriculum for the Scottish mandatory secondary school years, the SQA supporting materials for teachers and the N3-N5 biology textbooks disregard the problem of getting students to think about difficult evolutionary concepts such as deep of time (the concept of geological time), phylogeny and population thinking.

This finding reveals that the development of the biology curriculum has ignored key issues and concepts related to teaching evolution reported by literature and research. For instance, the argumentation that key biological concepts are misunderstood because of the persistence of ingrained essentialist assumptions that impede population thinking to be integrated in the scientific literacy has been disregarded (Hull, 1965; Gelman and Rhodes, 2012). In addition, the key concept in evolution that all living species are related by descent from common ancestry and therefore that evolution is substantially the theory of evolutionary trees and phylogeny does not emerge from the biology curriculum and the textbooks (Baum and Offner, 2008).

Phylogenetic trees enable students to understand the fact that all life is related and that this relationship goes back about 3.5 billion years to a universal ancestor. Phylogeny also integrates evolutionary concepts throughout the science curriculum (Offner, 2001). In fact, they illustrate the important principle that classification, anatomy, physiology, among other branches of biology, reflect evolutionary relationships. The more recently that two organisms had a common ancestor, typically the more closely they are classified, the more similar are their anatomical and physiological features, the more their DNA is alike. In other words, phylogenetic trees provide students with an organisational framework for structuring knowledge of biological diversity (Baum and Offner, 2008). Indeed, scientists and educators agree that it is impossible to understand evolution without the skills for interpreting phylogenetic trees (O’Hara, 1997).

Among the pedagogical and philosophical issues related to teaching EB, I believe that the strong emphasis on microevolution in biology education that emerges from this research, the virtual lack of understanding of the history of life on our planet (Catley, 2006), that is the deep of time, and the difficulty of assimilating population thinking (Hull, 1965; Mayr, 1975; Gelman and Rhodes, 2012) may be at the base of the predominance of typological thinking in biological taxonomy. I would argue that the persistence of Essentialism in taxonomy has tremendous implications in human classification and in the social construction of biological citizens and identities.

Many racist theories are underpinned by typologist assumptions (Mayr, 1975), such as the assumption that human populations are characterised by typical features that separate them by a distinct gap. Based on this assumption, the distinction between white/non-white people, for instance, risks to foster the belief that white people have some characters that other humans do not. In fact, Gelman and Rhodes (2012) report that the belief that two people from the same so-called race share more genes with each other than two people from different races is common. Therefore, it is difficult to understand the reason for which a secondary school biology framework should not promote the key idea of population thinking for which each individual, in the world, has thousands of features that can vary to a certain extent, independently from the others.

It has been argued that widespread problems in both acceptance and understanding of evolutionary biology stem from religious beliefs (Mazur, 2004). My research suggests that the issue is more complex and that biology curricula and textbooks can play a significant role. This finding can be related to Evans and her co-authors' position when they highlight "a substantive failure on the part of the public education to provide an adequate foundation for comprehending evolutionary theory" (Evans at al., 2010: p.2). On the one hand, the concern with religious belief might be suggested by the choice made by the curriculum developers and textbooks' authors to focus on microevolution and ignore macroevolution. Only the themes of microevolution, including natural selection, are briefly considered in the Scottish curriculum. The fact that in the textbooks microevolution is privileged with respect to macroevolution could suggest a response to religious concern. In fact, research show that many creationists accept evidence for microevolution, such as the selection of pesticide-resistant insects, although they reject macroevolution (Evans et al., 2010).

Microevolution is the process that consists, for instance, in the selection of antibiotic-resistant bacteria within a population made of both resistant and non-resistant strains. Macroevolution is instead those outcomes of evolution responsible for the generation of new taxa. It has also been argued that macroevolution in education is an even thornier issue than microevolution partially because the educational research on the issues of teaching and learning macroevolution is not so developed as the research on the conceptual problems in teaching and learning microevolution (Catley, Novick and Funk, 2012).

On the other hand, the data of this study do not allow me to state with certainty that the authors of the textbooks were concerned with creationist views, as evolution is presented as a fact, in contradiction with the concern that sensitivity to the creationist students may play a role. In addition, in this analysis of the issue, I would like to highlight that, in Europe, the non-acceptance of evolution because of fundamentalist religious beliefs only affects a minority of people. For instance, a cross-national study of the United States and nine European nations reveals that in the UK only 7% of adults think that evolution is false (Miller et al., 2006)

The data emerging from my study illustrate that the biology curriculum and the textbooks do not make any effort to develop phylogeny and population thinking in students and show that they do not take into account the intuitive reasoning processes that may be a constraint for the students' understanding of biological phenomena (Evans, 2000, 2001; Bloom and Weisberg, 2007; Evans et al., 2010). Interestingly, Williams (2009) points out that a reason for people's misinterpretation of evolution depends on its poor representation in some science textbooks that allows the misconceptions that are established in childhood to persist.

The misconceptions that William refers to consist, for instance, in the fact that pre-school age children tend to assume that biological categories “display inferential richness, sharp boundaries, immutability and innate potential” (Gelman and Rhodes, 2012; p.6). Rhodes and Gelman (2009) also illustrate that while pre-school children consider a hammer and a screwdriver to be the same kind of objects, they do not accept that pig and cow are the same kind of animal, believing that animal categories have sharp and permanent boundaries.

Rather than concerns with fundamentalist religious beliefs, the data of my study suggest a concern with misconceptions and the anxieties that young people may have about cloning and other science applications. From such point of view, the examples and the case studies of the textbooks should be interpreted. These examples are, among others: the barley resistant to heavy rain; the rice plant that is more resistant to the cold; the GM cotton plant resistant to the bollworm; the GM maize plants resistant to caterpillars and the European corn borer moth; the potential uses of stem cells in the treatment of people suffering from leukaemia and in repairing corneal damage; embryonic stem cells of potential use for future treatment of diabetes, Parkinson’s and Alzheimer’s diseases; products of genetic engineering of medical values such as insulin and human growth hormone; golden rice, blight resistant potatoes, tomatoes with a longer shelf life and strawberries of increased size.

The data of my research seem to validate the idea that, in every society, school textbooks play a role in the process of constructing legitimated ideologies and beliefs and may reflect the practices, knowledge and values of powerful groups in society (Nicholls, 2003). A clear ideology emerging from the analysis of the textbooks is that of a humanity dominating nature intended to end world hunger and capable of changing the genetic makeup of bacteria, animals and plants in order to produce giant fruits, useful drugs. This is also related to the choice of the curriculum developers and authors not to include any introduction to natural history and human evolution. This choice does not seem to be informed by the research showing that an element that makes teaching EB more difficult is the fact that macroevolutionary processes occur over very long periods of time and thus they cannot be observed directly (Catley et al., 2012).

The issue of the deep of time is a very important factor in the understanding of evolutionary processes. For instance, the hypothesis that a population can change complex characters over the time of a generation is not tenable. Neither is the idea that complex features can appear over the time of a few centuries or of a few millennia. The geological time scale is of millions of years. This feature makes the essentialist philosophy that positions a clear-cut division between humanity and nonhuman animals difficult to defend. For instance, the idea that complex features such as intelligence and the capacity for morality have emerged in a single step is not tenable from an evolutionary biology point of view.

From the textbooks, it is very difficult to grasp the position of modern biology, according to which humanity is a very short branch of the tree of life where every living being is related to the others, including the sturgeon that, as I have mentioned, one of the textbooks describes as the source of the delicacy caviar (Cook and Thornhill, 2015). The fact that we share 50% of our DNA with banana plants does not mean that banana plants can have moral capacity. However, laboratory and field studies in ethology, for instance, clearly reveal that the mind of the great apes, the living species most closely related to humans, show great complexity, intellectual abilities, complex socio-cultural mechanisms, language capacities and other similarities with our species, including the transmission of knowledge across generations (Russon et al., 1998).

The complexity of the minds of apes is shown also by a recent study that used a test originally developed for human infants (Krupenye et al., 2016). The study shows that apes understand if other individuals have mistaken beliefs about a situation. In addition, among natural scientists, there is the belief that it is unlikely that altruistic behaviours and empathy mechanisms have only emerged in humans (De Waal, 2008). Therefore, the notion of human dignity based on the dichotomy human-animal, the denigration of the intelligence of animals and the human-only paradigm of the theory of mind driven by the Aristotelian and Stoic idea that only humans have reason or beliefs is not tenable from a biological point of view. Sorabji (1995) maintains that, from the Stoics to Kant and to modern thinkers who plead the idea of human dignity, there is a link between the tendency to denigrate animals' intelligence and the rejection of the idea that humans have obligations of justice toward non-human animals.

Luke (1988) maintains that school textbooks are observable artefacts from which it is possible to recover traces of practices and policy: "That is to say that its particular words and relationships between words express exemplary historical cases of dominant rules of writing and reading, teaching and learning" (Luke, 1988: p.195). The analysed textbooks do not indicate that what Nussbaum calls 'the animal problem' is included among the dominant practices and policy. That is the critique of the idea that human dignity residing only in humans sharply divides humans from the rest of the animals. The GCE emerging from the document analysis does not suggest a kind of education useful to "cross the species boundary [enabling us] to understand the sufferings of animals […] to see that suffering as significant, as undeserved, and to see its potential termination as part of our scheme of goals and projects" (Nussbaum, 2003: p.14).

The choice to ignore 'trees of life thinking', population thinking and natural history has consequences for the image depicted by the textbooks on humanity in relation to other living things. In addition, the omission of the issue of deep time is also significant, as this concept is very important in the understanding of human intraspecific biodiversity. The textbooks fail to inform the students that a hundred thousand years, which is approximately the time of our presence on this planet, are not a sufficient time to significantly differentiate a species. In other words, the issue of deep time is central for understanding the reason why our species is biologically and genetically homogeneous. This aspect was highlighted by the biology teachers who participated in my study, but is ignored by the specification and the textbooks. Therefore, the question arises of whether it is legitimate to write secondary school textbooks and to build biology specifications that are not concerned with the need to include in the scientific literacy of the citizens the fact that the differences among Europeans, Africans, Asians and any other human populations are biologically very small and consist of a few genes, largely selected by the climate.

If we accept Lévi-Strauss idea that racism is a universal phenomenon common to any human societies based on the dichotomy culture/nature (e.g. civilised versus savage), the attempt to biologise the differences among human populations or human genders consists precisely in the attempt to relegate the others to the realm of nature (Lévi-Strauss, 1952). It is legitimate to wonder why the scientific education of young people should not present race and gender as social constructions, in the attempt to disclose the groundlessness of racism, sexism, xenophobia, and any other forms of biological discrimination.

Biology offers a number of examples. For instance, a number of epidemiological studies show that, on average, African Americans with darker skin have a higher mean blood pressure when compared to African Americans with lighter skin. The lack of population thinking education in the science curricula does not help lay people to avoid the naïve hypothesis of a biological relationship between having darker skin and higher blood pressure. Scientific evidence, in fact, shows that blood pressure is strictly correlated with dietary habits, which can be reasonably associated to the fact that on average darker-skinned people suffer hypertension because they have less access to valued resources (Duster, 2005). Even in medicine, the abandonment of the taxonomic use of human races has never been complete and young people might be very confused and legitimately ask the simple question of whether the supposed genetic diversity between two individuals of different race or ethnicity is real or not.

In theory, the most appropriate place to attempt to answer such questions is in the biology classroom. There are a number of information sources that, if provided to teachers and students by including them in the biology specification, SQA exemplification and textbooks, would support the negligibility of human biological differences. Some examples are as follows: on average, it is estimated that two unrelated individuals differ by 1 base in 1,500 in their DNA; naturalists consider such variability low when compared with other species and such low variability is an indication that *Homo sapiens* originated relatively recently and from a small population of ancestors (Jorde and Wooding, 2004); the largest amount of such a variation, about 85%, is among individuals within national or linguistic populations; only between 6 and 10% of the total variation, is among individuals classically defined as belonging to different races; the imprecision in the percentage (6 – 10%) depends mainly on the confusion about the number of human races, as there are proponents suggesting figures ranging from 3 to 200 (Barbujani et al., 1997); the physical traits normally used to define race (e.g. skin colour, hair form and nose shape) do not allow the achievement of a clear-cut racial division as, according to population thinking, such traits show a continuum over world populations rather than presenting sharp boundaries (Lewontin, 2006); people who have ancestry positioned in different races are often identified as belonging to one race, based on a few visible characters used in classical race definition (for instance, individuals with a black parent and a white parent are usually classified as black).

As I mentioned, the analysed textbooks exemplify the concept of continuous variation with human height. The use of skin colour would not only provide the teacher with an opportunity to criticize the division of humanity in races based on skin colour, but also the students with useful information for understanding human biodiversity. In fact, interestingly, the apportionment of skin colour shows, as expected, a different pattern from the other climate-dependent characters, with 12% of the total variation within or between local populations, and 88% among regions. Such findings are not surprising as the distribution of skin colour correlates with the distribution of ultraviolet radiation, with lighter skin colour at increasing distances from the equator. It is thus ironic that skin colour has dominated in racial classification when it is such a weak proxy for other biological traits, showing an atypical distribution pattern compared to DNA polymorphisms, genetic markers and craniometric traits (Relethford, 2002).

Darwin himself recognised that the traits most useful in order to study evolution are the ones he called ‘trivial’ (Cavalli-Sforza and Cavalli-Sforza, 1995). The following examples are cases in point. There are inhabitants of Southeast Asia, such as the *negritos* in Malaysia and in the Philippines, who share some common physical features with African populations. However, in spite of appearances, they seem to be the human population most genetically distant from Africans and they might be related more to the inhabitants of Oceania (Cavalli-Sforza and Cavalli-Sforza, 1995).

Figure 6.6 A negrito woman from the Philippines

This example should highlight the fact that all the genes that might be selected by the climate are generally expressed in external features. The external features of our body are in fact the interface with the environment. Unfortunately, just because they are external, people tend to ‘assume that differences of similar magnitude exist below the surface, in the rest of our genetic makeup. This is simply not so: the remainder of our genetic makeup hardly differs at all’ (Cavalli-Sforza and Cavalli-Sforza, 1995: p.124). A further case in point is provided by the example of mixed race couples, having babies with different skin colours, like the twins depicted in Figure 6.6. The application of the biological race perspective in such a situation, paradoxically, would make twins to fall in different races or ethnicity.

Figure 6.7 Twin brothers. Photograph: Martin Godwin for the Guardian (24 September 2001)

As I showed in the phenomenographic study chapter, sixteen participants made a statement that explicitly agrees with the idea that the differences among humans are biologically insignificant (table 5.6). These statements are in line with the idea that the biological forms of identities and citizenship are social constructions. Although there are no constraints in the CfE biology specifications that might make it difficult for the teachers to treat these issues, the biology framework or the textbooks do not offer supporting material or suggestions for including these issues, for example within the SSI to be discussed in biology classrooms. In fact, what is a better place than the biology classroom for educating people to discern between what is biology and what is culture?

Therefore, it is vital that teachers provide “a testable framework within which evidence-based evaluation of the history of life on Earth can occur. Tree thinking, a tool from evolutionary biology, provides such framework” (Catley, Novick and Funk, 2012: p.93). Tree thinking, or phylogeny, includes the set of skills required to interpret phylogenetic trees and other diagrams that depict evolutionary relationships among a set of taxa, such as groups of species. They are one of the most powerful predictive tools in modern biology (Catley, Novick and Funk, 2012). In addition, in this biological era, as human capacity to generate phylogenies has increased exponentially by advances in genomic data collection and computation, tree thinking is expanding its influence well beyond evolutionary studies (Catley, Novick and Funk, 2012).

The importance of the tree of life to society is not exclusively concerned with biological taxonomy. The value of the tree of life is relevant for guiding advances in fields of study as varied as epidemiology, gene identification and biodiversity (Yates, Salazar-Bravo and Dragoo, 2004). Indeed, phylogenetic tree diagrams are central to the work of modern science (Matuk and Uttal, 2012). For instance, phylogenetic studies are useful in tracing the natural history of emergent diseases. In fact, in order to develop effective control strategies against HIV, the understanding of the evolution of the human immunodeficiency virus is crucial for reconstructing its origin and deciphering its interaction with the immune system (Rambaut et al., 2004). Phylogenetic trees and tree thinking have been widely used to test the hypothesis of epidemiological clustering in suspected transmission chains of HIV. In fact, the relatedness among HIV samples obtained from infected individuals allows us to infer the direction of transmission between epidemiologically related individuals (Scaduto et al., 2010). Indeed, nowadays, the use of phylogenetic trees in epidemiological investigations has become commonplace (Romero-Severson et al., 2016). Ironically, in the United States, the use of phylogenetic analysis to support or reject criminal viral transmission cases has been first established in the court of Louisiana, the state that enacted the Balanced Treatment for Creation-Science and Evolution-Science Act in 1982 (Metzker et al., 2002).

Tree thinking is essential also to communicate to students and citizens the reasons for species diversity (O'Hara, 1997). Hendry et al. (2010) argue that many scholars and educators in biodiversity science have underappreciated the fundamental relevance of evolutionary biology. From this point of view, phylogenetic tree diagrams play an important role in species conservation efforts, as they document biodiversity, explain the causes of diversification, evaluate evolutionary responses to human disturbances and implications for ecological communities, ecosystems, and humans. Mace, Gittleman and Purvis

(2003) maintain that phylogenies can provide ways to measure biodiversity and to assess conservation priorities.

From this point of view, the fact that the CfE biology specifications and the textbooks do not suggest any link between biodiversity, evolution and phylogenetic studies is open to criticism. The picture emerging from the textbooks not only omits the ongoing transformation of life and the temporary nature of species. It also proposes the idea of animals and plants perfectly adapted in a given environment because if they were not adapted they could not survive. Therefore, this might foster in students the misconception that natural selection must result in perfection (Scott, 2012). It has similarities with the natural theologians of the seventeenth century who described nature as a harmonious and carefully administrated whole where plenitude, multiplicity, variety, symmetry, order, interconnection and adaptation were testimonies of the power and greatness of God (La Vergata, 1990). The fact that modern biology explains plenitude, multiplicity, variety, symmetry, order, interconnection and adaptation we find in nature with the theory of evolution does not emerge from the biology textbooks. Although it is stated that the concept of biodiversity should be developed through the course, the compulsory biology syllabus, as far as National 5, makes no link between biodiversity and evolutionary biology.

These examples support the idea of Matuk and Uttal (2012) for whom it is troubling that misunderstandings of phylogenetic trees are so common among students, citizens and, as Baum shows (Baum et al., 2005) even among professionals. It is also troubling that modern and ambitious curricula, such as the *CfE*, do not require as compulsory educational standards explicit training in phylogeny. In fact, students and all the other citizens of contemporary western societies, are likely to encounter phylogenetic trees, both in formal and informal social and cultural settings. Scholars agree that the increasing relevance of phylogenetic trees in issues related to health and environment policies make tree thinking a crucial skill for citizens to understand these issues (Matuk and Uttal, 2012; Baum and Offner, 2008; Catley and Novick, 2008).

The findings of my study are in line with other research that shows that, in the United States, confusion and misconception about evolution persist after biology instruction, suggesting that “these courses neither foster accurate mental models of mechanisms of evolution nor they instil an appreciation of the centrality of evolution to an understanding of the living world (Nehm et al., 2009: p.527). As a matter of fact, Nehm et al. maintain that textbooks and introductory biology courses result in reinforcing students’ preconceptions about evolution. The Scottish biology textbooks, like the American best-selling introductory biology textbooks segregate EB concepts in two sections, making the students fail to understand that evolution is the unifying theme in biology.

The absence of phylogenetic education in compulsory secondary school education is difficult to justify. It has been suggested by some of the participants of my study that constraints could emerge because of the young age of the students, considering some concepts of evolution difficult to be grasped by young people. However, I would respond that this could be a further reason for introducing and training students in this kind of thinking within the introductory biology classrooms.

Coley and Muratore (2012) point out that tree thinking, which describes the relations among species in terms of common ancestry, is in contrast with our naïve representations of taxonomic relations based on hierarchically structured classes. Therefore, there seems to be a need for training young people to tree thinking, rather than segregating it in the higher classes. Research illustrates that there are cladograms that seem to be easier for students to understand, than others (Novick and Catley, 2007); that it is possible to address some of the common misconceptions by representing taxa in a certain order instead of another (Baum, Smith, and Donovan, 2005); that there are exercises that seem to place students not only in a position to begin their approach to cladistics with a more positive attitude, but they also seem to improve the comprehension of what cladistics does and why cladistics is used (Goldsmith, 2003).

In conclusion, the corollary of my study is that EB has potential in GCE, but it is necessary to teach evolution better, restructuring biology curricula for the compulsory secondary schools and textbooks, in a way that fosters population thinking and awareness of phylogeny. I agree with the philosopher of science O'Hara (1997) when he argues that in the same way in which beginning students in geography need to be taught how to read maps, beginning students in biology should be taught how to read phylogenetic trees. It is understandable that some scholars "advocate that phylogenetic trees, such as cladograms, should figure in the visual lexicons of every scientifically literate person" (Baum et al., 2005: p.119).

6.5 Limitations of my study and implications for further research

I conclude this chapter by illustrating limitations of my research, by highlighting some implications of my study and by making suggestions for improvements and directions for future research.

In the methodology chapter, I justified the phenomenographic approach with the purpose to describe the different ways participants understand and interpret the proposal to educate for GC through teaching biology and in particular EB. However, in the literature, the phenomenographic assumption that there is congruence between what is said during the interviews and the conceptions which are researchers' objects of study has been questioned (Säljö, 1997). In fact, as the interviews were contextual, the assumption that the oral expressions of the interviewees are accurate accounts about their own conceptions has been critiqued (Sin, 2010). Aware of this, I exercised great caution in drawing conclusions from them and I integrated the interview data collection with the document analysis.

I am also aware of the fact that the data from the phenomenographic study would have had a greater significance if combined with quantitative data. As I discussed in the methodology chapter, the choice of a qualitative research resulted from the need to explore the complex social phenomenon of GCE through teaching biology, as experienced and understood by the biology teachers and as depicted by the biology curriculum. In addition, I selected methods based on qualitative data in accordance with my theoretical positions and ontological and epistemological assumptions. However, I am aware that if I had used a mixed-method research, integrating my study with, for example, a large-scale survey, for instance through an online questionnaire sent to all the secondary schools in Scotland, I would have probably increased the strength of my conclusions through quantitative analysis. In addition, a quantitative aspect to my research would have improved my study also with a content analysis of the textbooks, in the attempt to demonstrate the conceptual segregation of EB that I revealed with my qualitative analysis.

In order to provide the reader with instruments for evaluating the confirmability of my findings, in this section I list the possible biases that might have affected the findings. A problem can arise from the bias of the sample. As I selected the sample of the phenomenographic research by looking for volunteer biology teachers interested in participating in a study on GCE, the sample was biased as biology teachers critical with or unsympathetic to, delivering issues of GC in the science classrooms would be expected not to be present. I am aware that, knowing the conceptions of possible biology teachers who are critical might have provided my study with insights on constraints which I might have disregarded given the sample used.

The sample was quite varied. In fact, the teachers differ for age and experience. They were working in schools located in very different social backgrounds, in rural and metropolitan areas and distributed in a large geographic area of Scotland, from Campbeltown to Aberdeenshire. However, it was constituted only of biology teachers. By also exploring the conceptions of other stakeholders, in particular the conceptions of curriculum-developers and textbook authors, I would have arguably gathered some insightful data on why phylogeny and population thinking were disregarded by the biology framework for the compulsory secondary schools of Scotland.

With my study, I explored the teaching aspects of the issues at the centre of my research. I explored the teachers' conceptions, the biology specifications, the SQA supporting materials for teachers, the textbooks, the biology curriculum in relation to the CfE. However, I did not explore real teaching practices. Therefore, my study might be integrated by practitioner-researchers wishing to investigate the issues of my study. Such research might provide insightful data also on other very important factors I did not investigate. Notably, I did not consider the learning aspects and the conceptions of the other main actors in education, the students. I am aware that investigating aspects of learning related to the issues of educating for GC through school EB and the role of the students would add very valuable insights to this research.

A further possible line of research in this issue could involve conducting comparative studies in different European countries, first in order to understand if the absence in formal education of population thinking and phylogeny in the compulsory secondary school is an educational issue that is geographically widespread. Secondly, in order to understand the multifactorial problems that might emerge from the study of other national biology curricula.

Finally, a possible bias of this study might be concealed in my values and beliefs. For instance, this study disregarded any racialised views of the contentious debate about the so-called races and genomics. These attempts at the geneticisation of identities are, in my view, the periodical reappearance of genetic reductionism. These include instances that go from the "Cartwright's infamous 1851 invention of the diagnostic category Drapetomania" (Rose, 2007, p.156), that is the tendency of people with darker skin pigmentation to run away from slave plantations, to the more politically sophisticated attempts to make a link between population groups at the genomic level and the medical significance of genomic variations, in order to treat complex diseases and not only single gene disorders (Rose, 2007). In my beliefs, these are nothing other than attempts to biologise human cultural categories, which are what this thesis argues against.

In conclusion, I believe that my study has contributed to understanding of the myriad of problems related to teaching evolution. Research in this area shows that students carry a host of cultural and religious preconceptions about evolution on top of problems such as the difficulty of teaching natural selection properly, the unusual difficulties in mastering pattern and process of common ancestry and the common misconception that natural selection must result in perfection (Scott, 2012). This study clearly shows the potential role of biology curricula and biology textbooks in fostering views of EB that ignore the cosmopolitan facets of the Darwinian theory, disregarding the revolutionary potential in CE of phylogeny and population thinking. However, the hypothesis that alternative views of teaching EB may promote cosmopolitan values is still precisely that, a hypothesis.

For this hypothesis to become a theory, it needs empirical research in these directions. For instance, the possible outcomes of GCE through developing tree and population thinking, such as a sense of belonging to a global human society and the cosmopolitan values of compassion, should not remain implicit and should be assessed through the public examination system. Research and practices should thereby be conducted in this direction to allow an understanding of whether the view of nature provided by Darwinian common ancestry and tree of life can really promote cosmopolitan values. Darwin thought that there was a “grandeur in this view of life”. That is a grandeur that curriculum developers and textbook authors should not disregard.

Chapter seven Conclusions

At the turn of the century, the philosopher of science O'Hara (1997) argued that in the same way in which beginner students in geography need to be taught how to read maps, beginner students in science should be taught how to read phylogenetic trees. In this century, such an educational aim for citizens' scientific literacy is even more important. In fact, as the human capacity to generate phylogenies has increased exponentially by advances in genomic data collection and computation, EB with phylogenetic trees and tree thinking is expanding its influence well beyond evolutionary studies (Catley, Novick and Funk, 2012), to fields of study as varied as epidemiology, forensic, gene identification and biodiversity (Yates, Salazar-Bravo and Dragoo, 2004). Therefore, nowadays, citizens are frequently asked to make decisions concerning a variety of EB contemporary issues that rely on phylogenetic analysis (Catley, Novick and Funk, 2012; Yates et al., 2004).

This exploratory study, conducted in Scotland at the time of an important curricular reform, investigated teaching aspects of the interplay between school EB and GCE, in secondary school. Through a document analysis, I investigated the educational context in which Scottish biology teachers are acting and, through a phenomenographic study, I explored biology teachers' conceptions of the link between school biology/EB and GCE.

The document analysis revealed that, although within the scientific community it is generally recognised that the central and unifying key concept of biology is evolution, in the compulsory Scottish secondary school, EB is marginalised in the curriculum and in the textbooks and it is treated as a subject in and of itself. Macroevolution, natural history, human evolution and common ancestry are omitted in the compulsory secondary school science curriculum. In addition, the analysis illustrated that, although phylogenetic trees and tree thinking permeate almost all branches of biology (Baum and Offner, 2008), the compulsory science standards within the CfE do not require knowledge of phylogeny and most of the biology textbooks do not include a single phylogenetic tree. School EB in the compulsory Scottish secondary school results substantially in the theory of evolution focused on natural selection and the biotechnologies and the socioscientific issues emerging from them.

However, the declared flexibility of the CfE seems to be confirmed by the fact that the texts describing the biology specifications are open texts. This feature consists in the texts being incomplete and, thereby, open to be completed and generated by the interpretation of the readers (the biology teachers). Therefore, biology teachers, free to interpret and develop the biology curriculum with their competence, values and professional creativity may represent a key factor in developing the link between biology and CE. In fact, research findings show that teachers are a decisive component in reforming education (Pajares, 1992; Bybee, 1993; Handal and Herrington, 2003; Underwood, 2012).

The data of the phenomenographic study showed that three different global citizenship educator identities emerged within the biology teachers interviewed. The first identity relates the biology syllabus to issues of social justice, the second to environmental issues and the third focuses on the individual development of students. The same patterns emerged when the teachers' conceptions of the link between EB and GCE were explored.

In conclusion, I believe that this research provides a framework for understanding some of the issues associated with teaching EB with the aim to promote a sense of cosmopolitan belonging, in secondary school. For instance, I showed how textbooks illustrate adaptation, which is a mandatory topic of the biology CfE specifications, by using examples of animals and plants adapted to extreme environments. The topic could be an opportunity to inform young people that the genetic differences among the so-called human races are substantially limited to a few genes related to geographic adaptations. Therefore, through the invoked interdisciplinary approaches, students might be exposed to the idea that races are social and historical constructs used to divide humanity (Gould, 1996).

Data of my study seem to suggest that secondary school curricula should be revised, in a way that promotes the teaching of macroevolution starting from the early years of the school. Secondary school science textbooks and other didactic material should be reviewed, in such a way as to allow teachers to introduce macroevolution and phylogenetic trees and to link this to the thorny issue of human classification. Teachers should be specifically trained to develop students' tree thinking and population thinking, starting in the early years of the secondary schools, if not in the primary schools. Curriculum developers should be informed by the research on tree thinking in the educational contexts. Research should investigate more effectively the gap in teaching macroevolution and how to connect macroevolution to gender and ethnicity issues. In fact, at present, the educational purpose to promote tree thinking and to link the revolutionary common descent theory to human biodiversity is left to the discretion of the teachers. This does not mean that it is not happening anywhere.

For more effective interventions, science curricula should promote those skills related to tree thinking and to interpret cladograms and other phylogenetic diagrams. In fact, as citizens of western societies are frequently asked to make decisions concerning a variety of contemporary issues that rely on phylogenetic analysis, citizens, in order to be in a better position to make informed decisions about these issues, should be trained in tree thinking. These skills should be part of basic scientific literacy and therefore part of the aim of formal education.

With this study, by arguing for the inclusion of study of the common descent of all living beings in the biological literature for young citizens, the brotherhood of races, animals, plants and people, I hope to inspire the work and the approaches to EB of curriculum developers, researchers and teachers and I hope that the insights provided by this research can be useful in informing other science curricula in Europe which aim at linking school science with citizenship education.

Appendix 1: Interview Protocol

The University of Glasgow, charity number SC004401

Interview Protocol

a) What does Global Citizenship mean to you?
   b. And what does Global Citizenship Education mean to you?

b) As Biology teacher in Scotland, how do you view your role as a Global Citizenship educator?
   b. What are the challenges for a biology teacher in incorporating Global Citizenship issues?

c) What themes within biology do you think may have links with Global Citizenship?

d) What themes within Evolutionary Biology specifically do you think may have links with global citizenship?

e) In your view, how does evolutionary biology influence our understanding of our relationship with the rest of humanity?

f) In your view, how does evolutionary biology influence our understanding of our relationship with other living beings of the planet?

g) In your view, what are the implications of genetics for our understanding of the relationship between human races and ethnic groups?

h) In your view, what are the implications of genetics for our understanding of gender?

i) In your view, what are the implications of genetics for our understanding of human behaviour?

j) Which pedagogical (and interdisciplinary) approaches, if any, do you use in the biology classroom to incorporate aspects of Global Citizenship?
   b. Can you give some examples?

c. What issues (might you expect to) arise and how do you address these?

Additional Prompts

- Can you explain this?
- Anything else?

Appendix 2: Brief Questionnaire

University of Glasgow

The University of Glasgow, charity number SC004401

About myself

1. By the end of this school year, for how many years will you have been teaching altogether?

    ______________________ years

    (Please round to the nearest whole number)

2. Are you male or female?

    Female ☐ Male ☐

3. How old are you? under 25 ☐ 25 - 29 ☐

    30 - 39 ☐ 40 - 49 ☐

    50 - 59 ☐ 60 or more ☐

4. During your post-secondary education, what were your major or main area(s) of study?

Biology ☐ Chemistry ☐

Earth Science ☐ Physics ☐

Mathematics ☐ Education - Science ☐

Others ____________________

5. What is the highest level of formal education you have completed?

   a. Undergraduate (BSc or BA) ☐

   b. Postgraduate (PGCE/PGDE) ☐

   c. Postgraduate (MSc, MA, MEd, etc.) ☐

   d. Postgraduate research (PhD) ☐

6. What is the highest level of formal education you have completed that included a strong focus (at least 50%) on biology?

   a. Secondary school (GCSE / O-Level / Standard Grade ☐

   b. Secondary school (Highers, Advanced Highers, A-Levels, AS-Levels, etc.) ☐

   c. Vocational / NVQ ☐

   d. Undergraduate (BSc or BA) ☐

   e. Postgraduate (PGCE/PGDE) ☐

   f. Postgraduate (MSc, MA, MEd, etc.) ☐

   g. Postgraduate research (PhD) ☐

7. Have you been engaged in CPD relating to citizenship education?

   Yes ☐ No ☐

Appendix 3: Participants' details

Person	Gender	age range	teaching years	major area of study post sec
teacher 01	male	under 25	1	biology
teacher 02	male	30-39	10	biology & education science
teacher 03	female	50-59	31	biology
teacher 04	female	25-29	6	biology
teacher 05	female	under 25	1	biology
teacher 06	female	30-39	13	biology & geography
teacher 07	female	30-39	8	biology & chemistry
teacher 08	female	30-39	8	biology & chemistry
teacher 09	female	30-39	7	biology
teacher 10	male	50-59	35	biology
teacher 11	female	30-39	7	biology
teacher 12	female	30-39	2	biology
teacher 13	female	25-29	6	biology
teacher 14	female	50-59	28	biology
teacher 15	female	30-39	13	biology
teacher 16	female	30-39	7	biology
teacher 17	male	40-49	7	biology & chemistry
teacher 18	female	30-39	1	biology
teacher 19	female	40-49	12	biology & education science
teacher 20	female	30-39	2	biology
teacher 21	female	50-59	34	biology

Appendix 4: Email to the Local authorities

Dear [name of who was responsible for selecting research projects in the schools of the Local Authority],

I am an Italian secondary school science teacher studying for a PhD in Education at the Glasgow University. My study *Citizenship education in the Biology Classroom* investigates the relationship between citizenship education and biology education and includes an empirical phase which consists in interviewing science teachers.

For such a reason I am writing to ask the permission to interview secondary school biology teachers working in your local authority.

You find attached the request with a more detailed description of my project[1], but please do not hesitate to contact me […] or my supervisor, […], if you need further information.

I am looking forward to hearing from you.

Yours sincerely

[1] and only for the Glasgow City Council also the *Research Evaluation Questionnaire* and a copy of the interview protocol

Appendix 5: (E)mail to the principals

Dear Principal,

I am writing to ask your permission to possibly interview the biology teachers working in your schools, in order to provide my research *Citizenship education in the Biology Classroom* with useful insights.

I am an Italian secondary school science teacher studying for a PhD in Education at the Glasgow University. My study is about the relationship between citizenship education and science education. I am really interested in investigating such an issue in Scotland because of the Curriculum for Excellence. In several European countries it is common the demand for a reform of scientific curricula in order to make the scientific knowledge relevant to the life of the citizens in their society. In most of those countries (for example in England and in Italy) citizenship education is a discrete subject associated with history. In Scotland, on the contrary, the *Curriculum for Excellence* assigns a central role to citizenship education, promoting the adoption of an integrated interdisciplinary approach. As a consequence, biology teachers have to actively contribute to citizenship education. For this reason, Scotland offers a special field of enquiry for my research. I am interested in interviewing the teachers in order to understand how they make choices about curriculum design and pedagogy, and how they interpret and mediate evolutionary biology in their practice as citizenship educators.

I have the ethical permission from Glasgow University for carrying out my research and I was given the permission by the office of Education of your local authority for contacting you.

The interviews will be anonymous, will be last on average 40 minutes and will take place in your school. You find attached the interview protocol in order to make you aware of the questions that will be covered.

Please do not hesitate to contact me […] or my supervisors […] if you need further information.

I am looking forward for hearing from you.

Yours sincerely

Appendix 6: Baudelaire's poem *The Chats*

Cats

Both ardent lovers and austere scholars
Love in their mature years
The strong and gentle cats, pride of the house,
Who like them are sedentary and sensitive to cold.

Friends of learning and sensual pleasure,
They seek the silence and the horror of darkness;
Erebus would have used them as his gloomy steeds:
If their pride could let them stoop to bondage.

When they dream, they assume the noble attitudes
Of the mighty sphinxes stretched out in solitude,
Who seem to fall into a sleep of endless dreams;

Their fertile loins are full of magic sparks,
And particles of gold, like fine grains of sand,
Spangle dimly their mystic eyes.

— Translated by William Aggeler

Appendix 7: Biology Progression Framework (http://www.ssc.education.ed.ac.uk/)

Organisers	Key areas			
	Experiences and outcomes	National 3	National 4	National 5
Planet Earth Biodiversity and interdependence	Sampling and identifying living things from different habitats to compare their biodiversity and suggest reasons for their distribution. SCN3-01A	Sampling and identifying living things from different habitats to compare their biodiversity and suggest reasons for their distribution.		
	Interdependence.		Interdependence.	Energy in ecosystems.
	Adaptation for survival.		Adaptation for survival.	
	Impact of population growth and natural hazards on biodiversity. SCN4-01A		Impact of population growth and natural hazards on biodiversity.	Human impact on the environment.
	Photosynthesis SCN3-02A	Photosynthesis		Photosynthesis
	Photosynthesis limiting factors.		Photosynthesis limiting factors.	
	Propagating and growing plants.		Propagating and growing plants.	
	Commercial uses of plants. SCN4-02A		Commercial uses of plants.	
	Factors affecting respiration. SCN4-02B		Factors affecting respiration.	Respiration.

	Different types of chemicals in agriculture, the alternatives and their impact on global food production. SCN3-03A	Different types of chemicals in agriculture, the alternatives and their impact on global food production.		
	Nitrogen cycle. Fertiliser design and environmental impact. SCN4-03A		Nitrogen cycle. Fertiliser design and environmental impact.	
Biological systems Body systems and cells	Structure and function of organs and organ systems and their role in sustaining life. SCN3-12A	Structure and function of organs and organ systems and their role in sustaining life.		Control and communication. The need for transport. Effect of lifestyle choices on animal transport and exchange systems.
	Biological actions to maintain stable body conditions. SCN4-12A		Biological actions to maintain stable body conditions.	
	Learned behaviour in response to stimuli linked to species survival. SCN4-12B		Learned behaviour in response to stimuli linked to species survival.	
	Role of technology in monitoring health and improving quality of life. SCN3-12B	Role of technology in monitoring health and improving quality of life.		
	Structure and variety of cells and their functions.	Structure and variety of cells and their functions.		Cell structure. Transport across cell membranes.

	SCN3-13A			Cells, tissues and organs.
	Cell division and its role in growth and repair.		Cell division and its role in growth and repair.	Stem cells and meristems.
	Therapeutic use of cells. SCN4-13A		Therapeutic use of cells.	
	Different types of microorganisms and how microorganisms growth can be controlled. SCN3-13B	Different types of microorganisms and how microorganisms growth can be controlled.		
	Properties and use of enzymes and microorganisms and use in industries. SCN4-13B		Properties and use of enzymes and microorganisms and use in industries.	
	Body defences against disease and role of vaccines. SCN3-13C	Body defences against disease and role of vaccines.		
	Controversial biological procedures. SCN4-13C		Controversial biological procedures.	
Inheritance	Fertilisation and embryonic development and risks to embryo. SCN3-14A	Fertilisation and embryonic development and risks to embryo.		
	Growth and development of different organisms. SCN4-14A		Growth and development of different organisms.	
	Function of DNA.	Function of DNA.		

	Risks and benefits of DNA profiling. SCN3-14B	Risks and benefits of DNA profiling.		
	Sexual and asexual reproduction and their importance for survival of species. SCN4-14B		Sexual and asexual reproduction and their importance for survival of species.	
	DNA, genes and chromosomes.		DNA, genes and chromosomes.	DNA and production of proteins. Proteins and enzymes.
	Genetic inheritance. SCN4-14C		Genetic inheritance.	Variation and inheritance. Genetic engineering. Adaptation, natural selection and evolution of species.

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