ASTE Series in Science Education

Susan K. Stratton
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Educating Science Teachers for Sustainability

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Foreword

In times when teachers around the globe are held to account by the performance of their students in international comparisons such as the Programme for International Student Assessment (PISA) (OECD, 2012), which focus on literacy, numeracy, and science, it is a challenge for them to engage in something as ill defined as "sustainability." In times when many of us, including our students, spend many waking hours gazing at an electronic screen, it is a challenge to connect meaningfully with the complex issues of sustainability affecting our world. In times when schools are increasingly seen as the manufacturers of the "human capital" needed to serve the economy and as places where the seeds of consumerism can be planted at an early age, it is a challenge to reorient teaching and learning to counter this status quo. These challenges become even more imposing when vested interest groups act to maintain hegemonic unsustainable practices for their own benefit at the expense of the Earth as a whole.

It is in these times that this book on science teacher education for sustainability appears. Surprisingly, there are parts of the world where there is space for teaching and learning in a sustainability-oriented education program. Several factors, often in combination, seem to be critical for such an education to occur, such as available space for a localized curriculum; the presence of a school ethos conducive to connectivity and place-based learning; a culture of reflexivity as opposed to a culture of accountability; a local community concerned about sustainability; and the vision, leadership, and capacities of key educators.

In the midst of these changing and challenging times, the education research community is paying attention to global sustainability too, and it is ahead of educational policy in this respect. The American Education Research Association has recognized the environment and sustainability as key areas of education and research. The Nordic Educational Research Association chose education for sustainability as its main conference theme in 2013. The European Educational Research Association recently approved a new network on Environmental and Sustainability Education (ESE) and declared "the role of education in societal transitions" as the main theme for the 2015 conference. Leading education scholars such as Martha Nussbaum, Michael Apple, and Gert Biesta, who early in their

careers paid little attention to global sustainability challenges, are now strong advocates for strengthening the role of education in cocreating more equitable, democratic, responsible, and meaningful ways of living (see Apple, 2010, 2013; Biesta et al., 2013 and Nussbaum, 2010).

It may come as a surprise to find that there are countries where the entire school system has adapted to the challenges of teaching for sustainability while also doing well on international comparisons (Ählberg et al., 2015). Finland is often used as an example of a country where schools are permitted to develop their own localized curricula working on existentially relevant issues without losing sight of the so-called basics (Sahlberg, 2011). It helps, of course, that Finland is a country where teachers have a high status in society, are well paid, and are encouraged to research their own practice (Rasku & Kinnunen, 2003).

As the contributors to this volume point out, at the macro (societal/national) and meso (school/community) levels, there are differences in the conditions and challenges for initial teacher education and for subsequent professional development for education and learning with sustainability in mind. But what about the micro level (the individual)? Sustainability, which has become an inevitably ill-defined and ill-structured concept, poses didactical challenges as well. Sustainability represents what some refer to as wicked problems: problems that defy definition, have no single solution that works always and everywhere, writhe in ambiguity, and are submerged in conflicts of interest among multiple stakeholders. Sustainability, in a sense, cannot be taught. At best, teachers can create environments that are conducive to the exploration of sustainability issues around climate change, poverty, food security, biodiversity, and so on. As such, teaching sustainability becomes an educational design challenge, as can be seen in many of the contributions to this volume.

At the same time, we need to think about what we might call "sustainability didactics," for example, learning and instruction mechanisms, procedures, and tools that can help learners see connections and interdependencies, navigate socioscientific disputes, anticipate probable futures and imagine and articulate more desirable ones, cope with uncertainty and value, and utilize diversity. These powerful learning outcomes are increasingly referred to as sustainability competences or capabilities, and some speak of "sustainability literacy" (Cooke, 2010). In this volume, a number of chapters focus on the development of some kind of literacy, some referring to sustainability literacy, others to scientific literacy and environmental literacy, as foundational for understanding the complex nature of sustainability challenges and their associated socioscientific disputes.

Within the various discourses around Education for Sustainable Development (ESD), Environmental Education for Sustainable Development (EESD), Education for Sustainability Education (ESE), and Education for Sustainability (EfS), a tension exists between more instrumental interpretations and more emancipatory ones. The former interpretations, put bluntly, suggest that saving planet Earth, with human beings still existing as one of its species, is an end that justifies any means. Education is one key tool to help realize this goal. The latter interpretation holds that the purpose of education is to create opportunities for learners to become self-fulfilling,

self-determined, and critical citizens that reach their full potential: a process which will, in the end, result in a citizenry that will do the "right" thing. The essence lies not in *knowing* and in *reaching* the end but in the quality of the *means* that will engage citizens actively and meaningfully in a continuous search for doing the things we do better and for doing better things altogether. Doing better things together implies a questioning of stubborn routines that prove to be unsustainable as well as interrogating the values we live by and exploring alternative ones. Values and ethics in the classroom have been long neglected and will need to become an integral part of our education if sustainability is to be seriously addressed (Corrigan, Dillon, & Gunstone, 2007).

This tension between instrumental and emancipatory approaches runs through this volume too. Few of the chapters discuss the role of values and ethics and the ways these can become a part of science education toward sustainability. The reason for this frequent omission is not immediately clear but suggests that science educators may be wary of integrating values and ethics into their teaching. Nevertheless, this volume contains a unique compilation of research and reflections representing multiple vantage points stemming from different parts of the world—albeit mostly Western—that can help science educators and teacher educators in finding ways to meaningfully and purposefully embed sustainability into teaching and learning. This volume is a rich resource in exploring and contextualizing sustainability-oriented science education.

In their opening chapter, the editors explain that the overarching goal of this book is to open up "a conversation among science educators and others around the topic of educating science teachers for sustainability in a variety of settings, both formal and out-of-school." Given the scale of the challenges facing humanity in these times, there will need to be many conversations. There are some uncomfortable truths to be faced and some long-held beliefs to be shaken. We have provided some suggestions as to where some of those conversations might begin; we can only hope that we do not end up back where we started. Because then we will have failed and this book will have been written in vain.

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Preface

I recently joined my 6-year-old at school in the Southwestern part of the USA to eat lunch. I was surprised to witness the large amounts of food and waste generated by just one school lunch at one school. From Styrofoam trays and plastic water bottles to paper cups and plastic silverware, it all went into the garbage. I wondered how this could be different. Suppose my daughter's teachers instead incorporated sustainability ideas in their curriculum and modeled sustainable practices. In the USA, the National School Lunch Program feeds more than 30 million students each year. Studies have shown that kids throw away anywhere from 24 to 35 % of the food on their school lunch trays (Smith & Cunningham-Sabo, 2013). Maybe, instead the food options could be grown locally or, better yet, school grown and the resulting waste composted instead of sent to the local landfill. When children grow and cook their own food, they value it much more. Gardening and culinary education increases students' knowledge of nutrition as well as the variety of foods served at lunch. When students play a part in producing the food they eat and can choose the food they want on their tray, food waste in the school cafeteria decreases (Cluss, Fee, Culyba, Bhat, & Owen, 2014). Schoolyard gardens are prime locations in which students can engage in many problem-based learning activities. Students develop a sense of place as they learn about geographic seasonal changes and relationships to plant growth. Learning the importance of reducing waste, reusing materials, and recycling equips students to live sustainably.

An example of a school doing this in the Southern part of the USA is Green Charter School. The teachers at Green Charter School decided to include a unit on water use in their curriculum. In science, the students learn about the sources of water in their community, how water is treated for domestic use, and the wastewater system including how treated water is reused. The science students designed a rain garden system to capture rainwater for the school garden. Students in the culinary arts classes grow some of the food that they later cook and, as part of the unit, keep track of the amount of water they use in the garden (for growing the food) and in the kitchen (to prepare the food). The art teacher has the students engaged in a project, in collaboration with the water authority, to educate citizens about fertilizer use and runoff. In social studies, the students investigate how policy decisions about water

use have influenced development in the region. At the end of the unit, the school has an open house in which the students make presentations about how water is used in their city and make recommendations regarding methods they have found to ensure that the citizens will have sufficient high-quality water that will continue to support them as well as the diverse habitats and natural areas in the region.

This short vignette of what education for sustainability (EfS) could look like is not fiction. There are schools in the USA and elsewhere where this is happening (see, e.g., Barr, Leigh, & Dunbar (2011)). In it, we see some of the goals of EfS including the development of citizens that are aware of and concerned about learning ways of promoting an understanding of living within human and environmental needs and constraints (Connelly, 2002). While this school has been able to incorporate EfS into the daily lessons of many of the classes, there are other schools in which this happens but in a less systematic and concerted manner.

The focus of this book is the education of science teachers so that they can engage in EfS practices like those described in the vignette. We realize that for science teachers to be able to help educate students about the science of sustainable practices, science teacher educators will need to prepare pre-service and in-service teachers with adequate knowledge of the science behind sustainable living to ensure that their students will have opportunities to acquire the knowledge, values, attitudes, and commitment to sustain a healthy planet. Unfortunately, this is not a simple or a direct task. The idea of sustainability is dynamic and evolving with many interpretations. It includes the environment, society, politics, economics, the built world, and a discussion of sociocultural issues, values, and beliefs (see the introductory chapter for more details). Current paradigms for educating for sustainability include many topics that are controversial, value laden, and complex (Corney, 2006; Winter & Firth, 2007) and can be difficult to teach (Spiropoulou, Antonakaki, Kontaxaki, & Bouras, 2007). Yet, at the same time, many scholars agree that it is imperative for teacher educators, and specifically science teacher educators, to promote an awareness that will achieve a sustainable society (Corney & Reid, 2007; NGSS Lead States, 2013). Now is the time to begin!

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About This Book

The purpose of this book is to share knowledge and ideas about educating for sustainability including historical and philosophical analyses and pedagogical and practical applications in the context of science teacher preparation as they apply to formal and informal educational settings. This book is intended to be an international discussion among science teacher educators and scientists about how to approach the topic of EfS through multiple lenses including formal and informal settings, global voices, science teacher preparation, equity and diversity, college-level science courses for sustainability, and ethnoscience.

Educating for sustainability requires crossing borders and the cooperation of multiple groups from countries around the world. It is a joint effort among research in the STEM (science, technology, engineering, and mathematics) disciplines, the social sciences, and education (Khalifa & Sandholz, 2011). This book provides theoretical frameworks for researching and educating for sustainability. In addition, we illustrate pedagogical approaches to teaching the interrelations between humans and the global environment by demonstrating approaches to teaching about the values, behaviors, and lifestyles required for a sustainable future and positive societal transformation.

Some themes that have revealed themselves in these book chapters include

1. *EfS is a global endeavor that requires global citizenship*.
   Today, due to many factors including advances in technologies, we live in a global society. Western culture, as presented in school curricula today, exhibits many obstacles to EfS but at the same time presents countless possibilities as well. Science educators need to employ global thinking, using multifaceted approaches, to address global challenges related to sustainability. An attitude toward global learning and global education for sustainability will need to be developed throughout educational systems as well as on an individual level through concrete examples.
2. *Pre-service and in-service science teachers and science teacher educators will require professional development around how to engage meaningfully in EfS.*

Science teacher educators and science teachers lack a clear understanding of EfS, and most have little experience from either their formal or informal education with addressing sustainability in the classroom (Feinstein & Kirchgasler, 2015). Since many EfS topics are socioscientific in nature and have moral implications, many more experiences at many levels of science teacher preparation will be needed to address this challenge.

3. *EfS is a transformative and emancipatory pedagogy.*
   Educating for sustainability represents a new paradigm for the preparation of science teachers. It will require a new curricular vision that addresses the fundamental social purposes of education in the context of uncertainty and change. EfS stimulates a conversation about the role of science teacher education and teacher education in general in the creation and solutions of global environmental and social justice challenges.
4. *Values and ethics in the science classroom will need to be addressed in an integral manner in order for EfS to become the norm in science teacher education.*
   Science teacher educators and science teachers overall are often uncomfortable and even refuse to discuss controversial or sociocultural issues in their classrooms (Griffith & Brem, 2004). However, the organizing idea of sustainability is that the current generation will be able to meet their needs without jeopardizing the ability of future generations to meet their needs at the same or a better level than currently exists. Sustainability in science refers to the carrying capacity of an ecosystem or a balance between human systems and the natural environment and considers all living things as having equal rights and access to these resources. Inherent in this definition is the need for teaching values and ethics in science education. Ways to do this effectively will need to become a more integral part of science teacher education.

What's in This Book?

The chapters that follow demonstrate a variety of pedagogical approaches to teaching science teachers about the interrelationships between humans and the global environment. This book is unique in that the focus is exclusively on science teacher education.

The first part of the book is an introduction to the field of education for sustainability and provides a theoretical framework for understanding EfS and its relation to sustainability, sustainable development, and environmentalism. The second part focuses on the preparation of science teachers to teach for sustainability in school settings. The ideas of a sense of place, sustainability literacy, ecojustice philosophies, ecology disrupted, and field-based, project-based experiences for science teachers are introduced in this part. These views expand our understandings of the importance of representing the interdependence of science learning and

teaching within the cultural, social, and contextual factors of our complex world. Chapter 2 is particularly positioned to introduce how pre-service elementary teachers view sustainability in the USA. This is followed by Chap. 3 and a discussion of science teacher education preparation programs that prepare these teachers to teach from a sustainable viewpoint. Chapters 4, 5, 6, and 7 then provide examples of courses and programs in science teacher education that use education for sustainability as a framework for educating science teachers. Finally, in Chap. 8 of Part II, the strategy of using learning progressions and scientific argumentation to facilitate science teachers' understanding of sustainability as a way for teachers to evaluate the views of their students and their own views is discussed.

The third part of the book emphasizes science teacher education for sustainability in out-of-school settings. Chapters 9 through 15 provide examples of science teacher education for sustainability in a variety of settings, exchanges with other countries and contexts in regard to sustainability, and uses of technology tools to explore the complexities of sustainability. In these chapters, we find examples of science educators creating their own stories and identities as educators for sustainability as they deal with the controversial, value-laden, and complex issues that comprise EfS.

In the fourth part of the book, science teacher educators bring to the forefront international perspectives on educating science teachers for sustainability. While various chapters in Part II and III of the book are authored by individuals from a variety of countries, in Part IV we focus on particular viewpoints from the perspectives of authors from Australia, Sweden, Cambodia, the UK, and Ireland. In the chapters from Australia, Canada, the UK, and parts of Europe are found examples of a critical approach to sustainability that takes into account contextual and political factors affecting people's lives (Dillon, 2014), which is often missing in discussions in the USA. International perspectives are especially important as we consider ways to educate science teachers for sustainability because of its complex topics such as poverty alleviation, human rights, peace and security, cultural diversity, biodiversity, food security, clean water and sanitation, renewable energy, preservation of the environment, and sustainable use of natural resources, all of which require a global approach (Kilinc & Aydin, 2011).

Finally, in the last part of the book, we, the editors, further elaborate on the themes represented and brought forward in these book chapters. We consider multiple ways to frame the discussion of educating and preparing science teachers for sustainability. We reference U.S. standard documents such as the Next Generation Science Standards (2013) and discuss global perspectives on science teacher education (Lederman & Lederman, 2015) as related to EfS. We raise challenges as well as offer possible counterperspectives when thinking about EfS. One such counterperspective is addressed in the afterword. It is our hope that this book and these book chapters will encourage a continued conversation around educating science teachers for sustainability. We believe that only through a broad and diverse conversation that draws on different sources and conclusions can we address the

critical and urgent need for a new paradigm in science education in which science teachers understand ways in which they can bridge the gap between science and education by educating for sustainability (Tilbury & Mulà, 2009).

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Contents

Part I
Introduction

Chapter 1
Theorizing Sustainability: An Introduction to Science Teacher Education for Sustainability

Allan Feldman and Molly Nation

At the time of this writing we find ourselves in a situation in which the earth's ecological system is under significant strain as a result of human activity. On the global scale the rapid release of carbon dioxide and other heat trapping gases into the atmosphere from the burning of fossil fuels, industrialized farming, and other human activities is causing substantial and unpredictable climatic changes. On the local level the growth of megacities tests the limits of our ability to provide clean water and sanitation to dense concentrations of people. Given all of this we find for those of us who live in the developed world asking "How can we maintain our current standard of living?" while those of us living in the developing world are asking "How can we increase the quality of our lives?" all while trying to do what is necessary to mitigate the environmental problems. That is, how can we sustain the former and engage in sustainable development in the latter? One way to respond to these questions is through education, both formal and informal. That said, we recognize that the problem of creating a sustainable world is a complex one in which the "three pillars" of sustainability – economic, social and environmental factors – and the relationships among them, need to be considered systemically. Added to this are political (Bentham, 2013) and technical (Mihelcic et al., 2003) considerations that increase the complexity of the problem. When put together we envision an interconnected system of the Natural World, Built World, Economic World, and Political World immersed in a social and cultural milieu (see Fig. 1.1).

The overarching goal of this book is to begin a conversation among science educators and others around the topic of educating science teachers for sustainability in a variety of settings, both formal and out-of-school. We attempt to provide a balanced view of the topic by exploring relationships among different worldviews and from a variety of individuals. We realize that this is a continuing and shifting discussion in which many factors such as historic, cultural, political, and economics

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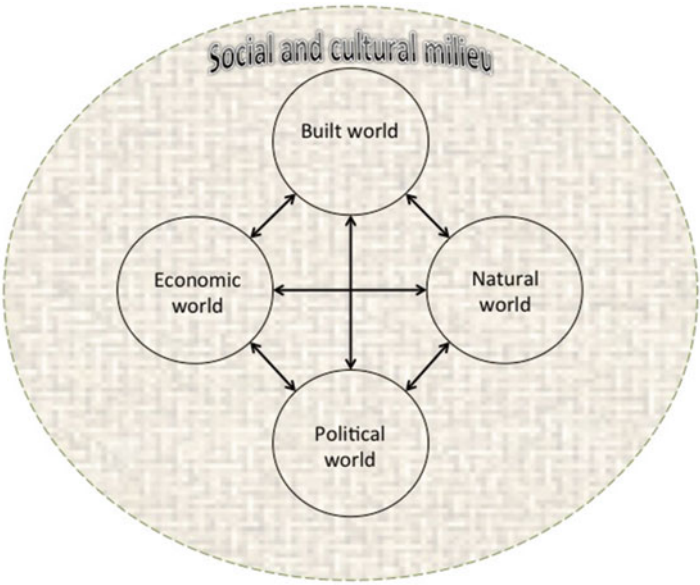

Fig. 1.1 Sustainability as the interaction of the natural, built, economic and political worlds in a social and cultural milieu

influence and interact with each other as a part of the ESD conversation. We realize that this necessitates a joint effort between research in STEM, the social sciences and education (Khalifa & Sandholz, 2012). Before providing more details about the content of the book, we turn to addressing some issues related to education and sustainability.

The Language of Education and Sustainability

Much has been written about the way in which language and discourse shape how we think about what we do in relation to education, the environment, and sustainability (see Berryman and Sauvé (2013) for a discussion of these issues). Therefore, before proceeding, we believe it is necessary to clarify the ways in which we use some terms. As we suggested above, we distinguish between *sustainability* and *sustainable development* primarily by context. For those societies in which human needs – sufficient food, good housing, clean water and sanitation, universal access to health care and education, among others – are not met or are met poorly, we use the term sustainable development as "improving the quality of life while living within the carrying capacity of supporting ecosystems" (Munro & Holdgate, 1991, p. 10). We use sustainability in reference to those societies in which those needs have been met for the large majority of their populations, and for which a goal

could be the maintenance of a sustainable economy that can develop, but not necessarily grow, through improvements of knowledge, organization, technical efficiency, or wisdom (Munro & Holdgate, 1991). Obviously there is a gray area in between sustainability and sustainable development, both in relation to large regions and the local level. While making the distinction, we see them both as leading to a sustainable society, which would be achieved through an ethic of sustainable living that calls for people "to seek harmony with other people and with nature" (Munro & Holdgate, 1991, p. 8)

The difference between sustainability and sustainable development suggests that there should be a similar distinction between education for sustainability (EfS) and education for sustainable development (ESD). Most of the chapters in this volume refer to science teacher education efforts in the developed work and will use EfS. The other chapters will use the acronym ESD. However, because of the local nature of this work, there would be instances in which ESD is used for efforts in the developed world and vice versa.

Although we have decided to use the term education for sustainability for most of what is reported on here, we are aware that its use is contested. For example, Sterling (2003) distinguishes among education *about* sustainability, education *for* sustainability, and *sustainable education*. He bases the distinction on his critique of education from a whole systems thinking approach. He argues that education *about* sustainability is an accommodation with existing curricula, pedagogy, and other aspects of educational systems. For example, a sustainability concept such as carrying capacity could be added into an existing curriculum while having minimal effect on the school, or on the behavior of teachers or students. In addition, there might be unintentional conflicts between the newly added material and aspects of the original curriculum that may actually support unsustainability.

According to Sterling (2003) education *for* sustainability is also an adaption of existing educational systems, but adds critical reflection of it. The result can be that sustainability concepts get built into the curriculum in a way that reorients the existing system toward an ethic of sustainability. The central idea behind this approach is that people can learn what they need to know and do to live sustainable lives. *Sustainable education* comes about through a paradigm shift "which engages the whole person and the whole learning community, whereby the meaning of sustainable living is constantly explored and negotiated through living it" (Sterling, 2003, p. 286). From this perspective, sustainable living is *learning as sustainability* and comes about through transformation rather than reform.

UNESCO has published a set of guidelines for reorienting teacher education to address sustainability (Hopkins & McKeown, 2005). In it they, like Sterling, distinguish between education *about* sustainability and education *for* sustainability. To UNESCO the former can be thought of as the academic study of the characteristics and nature of sustainability or sustainable development. In this approach students might learn about the economic, social, and environmental need for a sustainable society. This could take the form of a theoretical or philosophical analysis, or case studies of relevant sustainability issues. However, there might be a distancing that is characteristic of much academic work that would separate the study of sustainability

from learning about how to engage in or make society sustainable. It is the latter that UNESCO sees as education for sustainability. This distinction is somewhat different from that of Sterling (2003) because it puts into the forefront the purposes or goals for teaching and learning about sustainability. Education about sustainability has as its primary purpose to increase the learner's knowledge – the *know what* of sustainability. It allows for a dispassionate and seemingly apolitical approach to including it in the curriculum. This is contrasted with education for sustainability, which has the normative purpose. That is, EfS has as its purpose to educate the populace to create a more sustainable world, as envisioned by the curriculum developers.

We believe that Sterling's and UNESCO's analyses make useful distinctions among different approaches to education and sustainability. We also believe that the approach that one takes is contingent upon social, economic, emotional, and political contexts of the educational situation. Therefore, we will refer to all the educational approaches that are reported in this volume as either education for sustainability or education for sustainable development, and let the readers decide whether Sterling's or UNESCO's or any other typology helps in understanding and enacting science teacher education for sustainability.

Environmental Education and Education for Sustainability

In addition to placing this volume within the spectrum of the various ways to think about education and sustainability, we feel that it is also important to relate EfS to conceptions of environmental education (EE). We find that the Julia Corbett's (2006) notion of a spectrum of environmental ideologies to be useful for our analysis. Corbett defines an environmental ideology as "a way of thinking about the natural world that a person uses to justify actions toward it" (p. 26). She labels the endpoints of her spectrum anthropocentric and ecocentric. As the term implies, an anthropocentric ideology is human-centered with the belief that there is a hierarchal ranking of the natural world with humans on the top. People who hold an anthropocentric environmental ideology make a sharp distinction between the natural world and the human world, with the former existing primarily to serve the latter. In contrast, those with an ecocentric ideology hold a more equitable view of the natural world, and see humans as being an integral part of it. Corbett stresses that most people hold views that are in-between these endpoints, but that in general, anthropocentric ideologies are the dominant beliefs in existing social structures.

Corbett (2006) describes five categories of environmental ideologies: unrestrained instrumentalism, conservationism, preservationism, ethics and values-driven ideologies, and transformative ideologies. She characterizes the first as an anti-environmentalist stance because it puts human needs above all over ecological considerations. Conservationism and preservationism are what most Americans think of as environmentalism. They are anthropocentric ideologies that recognize the need for conserving resources or preserving natural areas for human needs and

use. Ethics and values-driven ideologies are more toward the ecocentric end of the spectrum. People who hold these beliefs use human-based ethics and values to attach worth to the natural world. Corbett uses the examples of the US Endangered Species Act and the animal rights movement of how an ethical stance, for example stewardship, toward other non-human species can result in environmental action. Corbett notes that actions based on these ideologies do not require reformulation of existing economic, political, social, or cultural institutions. Therefore, they can be seen as reforming rather than transforming the social sphere. Corbett's most ecocentric category is transformative ideologies that "question the dominant environmental ideologies and call for extensive social change … [They] seek to transform a language and practice that constructs nature as a set of passive, inert resources for human benefit" (pp. 40–41). They call for a radical transformation of belief systems that would do away with a hierarchal view and recognize people as being one of many interdependent parts of the natural world.

For the most part the environmental movement in the US and its associated environmental education have been informed and structured by the more anthropocentric and less radical conservationist and preservationist ideologies. This has had a significant effect on the newer movement for sustainability and education for sustainability. For the most part, these newer movements can be thought of as extensions of environmentalism in which the complexities that are human, social constructs are considered. As a result, EfS can also be thought of as being associated with a range of ideologies. For example, Ruth Irwin (2008) distinguishes between "sustainability and ecology" and "sustainability and economics". An education for sustainability and education would be similar to environmental education guided by conservationist or preservationist ideologies. The resulting education has as its goals to help people learn what they need to do to sustain natural environments and why. As with conservationism and preservationism, sustainability and ecology is anthropocentric. It is also for the most part free of many of the social and complexities inherent in a vision of sustainability that pays attention to economic and social factors in addition to the environmental.

Sustainability and economics (Irwin, 2008) is highly anthropocentric and closely related to Corbett's unrestrained instrumentalism. It is a

> philosophical shift towards understanding the earth as a resource rather than a pure thing-in-itself. … [It] is the application of long-term projections on resource use, and the conservation and sustaining of resources for "future generations". These goals are to be achieved without jeopardising the incremental growth of economic prosperity. (p. 175)

As we make the distinction between environmental education (EE) and education for sustainability, we stress that EfS brings to the forefront the complexities that are human, social constructs. As a result EfS ought to take into account the complexities that arise from the possible conflicting concerns of a wide range of stakeholders that would require negotiation and reconciliation (Campbell & Robottom, 2008). When conceived of in this way, EfS would focus on "environmental issues for which there are discernable ecological, social and economic issues in dispute, and provide learners with opportunities to engage with and witness the resolution of these

issues" (p. 204). As it turns out, this is not easy to do in schools as evidenced by what we see in the US and in other countries such as South Africa (Bentham, Sinnes, & Gjøtterud, 2014) and Australia (Campbell & Robottom, 2008). Here in the U.S., where this volume is being edited, for the most part EfS has been a non-starter. For example, there is little to suggest that U.S. educators have acted upon or even been aware that the past 10 years have been UNESCO's Decade of Education for Sustainable Development (UNESCO, 2005c). When schools do take on the rhetoric of EfS what often happens is either a focus on the environment without attention paid to the other two pillars of sustainability, or a focus on how current lifestyles can be maintained or further developed given environmental constraints (Campbell & Robottom, 2008). Neither of these two options requires social or economic transformation, both of which would require discussion that would be labeled as political, and therefore undesirable in most U.S. schools.

Science Teacher Education for Sustainability

As part of UNESCO's Decade of Education for Sustainable Development it instituted a major effort to change the ways in which teachers are educated in order for them to be able to address sustainability in their teaching. As part of this effort it developed the document *Guidelines and Recommendations for Reorienting Teacher Education to Address Sustainability* (UNESCO, 2005b). In it they identified five societal goals that education for sustainability would address through the processes of public participation and community-based decision-making: "environmental stewardship; social equity, justice and tolerance; and quality of life for all peoples in this generation and the next" (p. 15). Based on these goals, UNESCO specified the following criteria for ESD projects:

- ESD is locally relevant and culturally appropriate … [It] is not imported from another cultural, economic or geographical region.
- ESD is based on local needs, perceptions, and conditions, but recognizes fulfilling local needs often has global effects and consequences … [It] is not "one size fits all," but must be created to account for regional differences.
- ESD addresses content, context, pedagogy, global issues, and local priorities.
- ESD engages formal, non-formal, and informal education.
- ESD is a life-long endeavor.
- ESD accommodates the evolving nature of the concept of sustainability.
- ESD deals with the well being of all three realms of sustainability – environment, society, and economy. (p. 16)

The first three criteria above require that EfS be culturally relevant, not just when responding to majority cultures but also to the multiple cultures of the students and teachers in multicultural settings. The next two basically encourage those who develop programs for EfS to use all educational venues and to recognize that it is not just students and teachers who need to be educated for sustainability, but also adults.

Finally, we are reminded that sustainability is a moving target, and that it is transdisciplinary in its need to address the three pillars.

What is missing from the above list of criteria, as well as from the many recommendations for all levels of educational systems (UNESCO, 2005a) is framing of the content of EfS. What is it that teachers ought to teach and students ought to learn when we educate them for sustainability? One possible source for this is the book *Caring for the Earth* (IUCN, UNEP, & WWF, 1991). The authors suggest nine principles for sustainability. They can be roughly divided into goals and strategies. The goals include respect and care for the community of life; the improvement of the quality of human life; and conservation of the Earth's vitality and diversity while minimizing the depletion of non-renewable resources and keeping within the Earth's carrying capacity. Their strategies for accomplishing these goals include changing personal attitudes and practices; enabling communities to care for their own environments; providing a national framework for integrating development and conservation; and forging a global alliance. It is possible to conceive of sets of content and skill standards that would help provide teachers and students with the abilities to implement the strategies in order to achieve the goals.

Approaches to Education for Sustainability

As we have reviewed the literature on education for sustainability, it became apparent that there are several prominent approaches to including sustainability in science classes. They can be roughly divided into two broad categories – approaches that place emphasis on the teaching and learning of science content, and approaches that emphasize sustainability.

Focus on Science Learning

Sustainability topics may be added to existing science content courses to motivate students or to provide contexts for the understanding of or application of science concepts (Albe, 2013). It has been argued for many years that by adding "real world" concerns to science classes, students find the content more interesting and more pertinent to their experiences. Sustainability topics can certainly fill that role (McFarlane & Ogazon, 2011), and may be one of the main reasons for their inclusion in traditional science courses. That said, while the inclusion of sustainability topics can motivate students, there is little evidence that suggests that their inclusion in the curriculum in this way has any lasting affect on students' actions outside of the classroom (McFarlane & Ogazon, 2011).

In addition to motivating students, sustainability topics can be used in science classrooms as the context for the learning of science content. This is becoming more widespread, especially within environmental and natural science courses. The