



# **A Failure Reveals Success: A Comparative Analysis of Environmental Education, Education for Sustainable Development, and Industrial Ecology Education**

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## **Abstract**

Although environmental education and education for sustainable development have become well-established areas of scholarship and practice, there has not been a similar development focused on “industrial ecology education.” A review of the historical context and guiding philosophies for each of these areas finds many similarities, as well as key differences. Environmental education traces its modern roots to the idealism of the 1960s and 1970s. It has focused mostly on improving environmental conditions. Education for sustainable development arose along with international concerns about social justice. It has emphasized general education as well as education about sustainability as necessary to ensure human prosperity. Industrial ecology, in its contemporary form, evolved as an applied approach to address environmental concerns and to meet sustainability goals. It has developed into a diverse, multifaceted approach to address the complexity inherent in industrial society. Education focused on industrial ecology remains decentralized, with core principles and tools being integrated into existing disciplinary programs as well as development of industrial-ecology-specific curricula. These efforts have not coalesced into a formalized, industrial ecology education. Rather than reflecting a shortcoming, this potentially offers a more robust method for applying industrial ecology principles and tools widely.

## Introduction

The impetus for this work lies in failure. A concerted effort to identify scholars studying the pedagogy of education about industrial ecology failed. This is not because there is a lack of education related to industrial ecology. Quite the contrary. The International Society for Industrial Ecology (ISIE 2013) has posted a list of industrial ecology courses available at more than 60 universities throughout the world. Degree programs explicitly labeled “industrial ecology” are available at universities in The Netherlands, Norway, Sweden, and Thailand. Numerous universities offer other degree programs that include industrial ecology in their pedagogy. With so many actual education efforts, why is there not a line of inquiry focused solely on industrial ecology education? In comparison, there are journals, conferences, professional associations, and university degrees dedicated to “environmental education.” Likewise, the concept of “education for sustainable development” (ESD) has its own journals and professional organizations.

A review of the origins and evolution of these fields suggests that the vagaries of historical context—when and how each of these concepts arose—and core emphases that form the foundation for each can explain, at least in part, why the paths that generated environmental education and education for sustainable development have not prompted a similarly formalized “industrial ecology education.” This review also reveals that industrial ecology may not need, or be well served by, having a concentrated education track.

This article is not intended to be a comprehensive historical review of these concepts or their philosophical underpinnings,

**Table 1** Timeline of key events in the development of environmental education, education for sustainable development, and industrial ecology education

Date	Environmental education	Education for sustainable development	Industrial ecology education
1969	<i>Journal of Environmental Education</i>		
1970	U.S. Environmental Education Act		
1971	National Association for Environmental Education (later North American Association for Environmental Education)		
1972	Stockholm Declaration		
1975	International Environmental Education Programme; Belgrade Charter		
1977	Tbilisi Declaration		
1980		World Conservation Strategy	
1981	Foundation for Environmental Education Europe (later "Europe" dropped)		
1987		Brundtland Commission report	
1989			Frosch and Gallopoulos (1989), "Strategies for Manufacturing"
1992	<i>International Research in Geographical and Environmental Education</i>	Agenda 21	U.S. National Academies of Science colloquium on industrial ecology
1995	<i>Environmental Education Research</i>		
1997		Thessaloniki Declaration	<i>Journal of Industrial Ecology</i>
2000		<i>International Journal of Sustainability in Higher Education</i>	International Society for Industrial Ecology
2001		Education for Sustainability Western Network (later Association for the Advancement of Sustainability in Higher Education)	
2002	<i>Applied Environmental Education and Communication</i>		
2005		UN Decade of Education for Sustainable Development	
2006	<i>International Journal of Environmental and Science Education</i>		
2007		<i>Journal of Education for Sustainable Development</i>	
2010		<i>Journal of Sustainability Education</i>	

but rather it highlights key points of context that are relevant to comparing the three focal areas. The literature cited herein does provide thorough reviews of the history of environmental education, education for sustainable development, and industrial ecology. See table 1 for a summary of key developments in the history of these topics.

## Environmental Education

### Historical Context

Although the first use of the phrase environmental education is debated (Carter and Simmons 2010; Disinger 1985), the concept can be traced at least as far back as Rousseau's eighteenth-century ideas for education that included careful

attention to the physical world and using the senses to learn (McCrea 2006). Romantic-era ideals greatly influenced thinking about the natural world and how to study it (Armitage 2009). Throughout the nineteenth century, authors, including Ralph Waldo Emerson, Henry David Thoreau, and George Perkins Marsh, continued to explore relationships among humans and nature (Carter and Simmons 2010). Although not focused explicitly on education, these works drew attention to concepts such as preservation and conservation that subsequently influenced the Nature Study movement in the United States (Kohlstedt 2005; Armitage 2009). Nature Study was an experiential, science-driven approach to education that, by 1900, was the accepted method for studying the natural world in public schools (Kohlstedt 2005; Armitage 2009). These parallel lines of attention to the state of the environment and

its links to education continued into the twentieth century, with the 1948 Conference for the Establishment of the International Union for the Protection of Nature. This meeting prompted increased attention to environmental issues globally and set the stage for the modern environmental movement and, subsequently, what is now called environmental education.

In 1969, William Stapp, a professor in the Department of Resource Planning and Conservation at the University of Michigan, and his graduate students developed a definition and major objectives for the concept of environmental education. These were published in the first issue of the *Journal of Environmental Education* that year. In 1971, the National Association for Environmental Education (now the North American Association for Environmental Education) was founded. Britain experienced a similar evolution, with various movements (e.g., environmental studies, outdoor education, conservation, and urban studies) contributing to increased attention to environmental issues in curricula throughout the 1970s (Tilbury 1995).

Environmental education thus began its contemporary history under the powerful imprimatur of the modern environmental movement. This contributed to regulatory mandates and funding in the United States as well as formalizing the concept internationally. In 1970, President Nixon signed the Environmental Education Act, which authorized U.S. federal agencies to develop and fund programs to support environmental education in public schools and in communities (Public Law 91-516; October 30, 1970). Although funding through this act was eliminated in 1975, environmental education had, by that time, been inculcated into the educational paradigm and was perpetuated by professional associations and other nonprofit organizations that focused on community education and teacher training (Carter and Simmons 2010).

The environmental movement was global and so was attention to education. The Stockholm Declaration from the United Nations (UN) Conference on the Human Environment in 1972 stated that education is essential to promote “responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension” (UNEP 1972, 3). This prompted the formation of the UN Educational, Scientific and Cultural Organization/UN Environment Programme (UNESCO/UNEP) International Environmental Education Programme in 1975, which subsequently led to several international meetings on environmental education. At the International Workshop on Environmental Education in Belgrade, Yugoslavia in 1975, attendees generated the Belgrade Charter that outlined goals and guiding principles for environmental education. Two years later, the first Intergovernmental Conference on Environmental Education was convened in Tbilisi, Georgia. The goals in the resulting Tbilisi Declaration are still considered the definitive statement on what environmental education is and ought to be (Carter and Simmons 2010). In 1981, the Foundation for Environmental Education Europe (now the Foundation for Environmental Education) was established.

## **Emphasis**

Because the environmental movement was the catalyst, environmental education clearly reflected the philosophy of this broader movement in its definition and approach. Among the most widely cited and accepted definitions of environmental education is this one from Stapp and colleagues: “Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution” (Stapp et al. 1969, 30). The Belgrade Charter (1975) is also often cited with its stated goal for environmental education “to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitments to work individually and collectively toward solutions of current problems and the prevention of new ones” (UNEP 1975, 3).

Both emphasize the importance of educating the general public so that they can take action. The format for educating included formal approaches with curricula for elementary through university students, as well as informal approaches directed at communities and the general public. In delineating a rationale for environmental education, Stapp and colleagues emphasized the interconnectedness of “man, culture, and the biophysical environment” and wrote that to understand these connections requires being familiar with “urban and rural design including transportation systems, spatial patterns of development, and aesthetic qualities which have a major impact on the functioning of society” (Stapp et al. 1969, 31). The ultimate goal of environmental education was to “advance human welfare.” The Belgrade Charter (1975) emphasized taking a new approach to development that did not encourage economic growth at the cost of environmental harm and emphasized that “environmental education should consider the environment in its totality—natural and man-made, ecological, political, economic, technological, social, legislative, cultural and esthetic” (UNEP 1975, 4). The Tbilisi Declaration (UNEP 1977) reaffirmed these interrelationships as central to environmental education.

The underlying premise for environmental education was that if people *knew* about their relationship to the environment, then taking action to avoid or fix environmental issues would be logical and feasible. This line of thinking fit well with the grassroots and public advocacy attitude of the 1960s and 1970s. It also fit well with prevailing ideas about negative environmental concerns, as well as their causes and solutions. There was a naïve presumption that environmental issues could be isolated by media (e.g., water, air, and land), that these issues reflected linear relationships, and therefore once the relationships were understood, it was a simple matter to apply technology and regulation to address those aspects of the relationships that caused environmental harm. William Ruckelshaus, first director of the U.S. Environmental Protection Agency, has been quoted as saying, “We thought we had technologies that could control pollutants, keeping them below threshold levels at a

reasonable cost, and that the only things missing in the equation were national standards and a strong enforcement effort. All of the nation's early environmental laws reflected these assumptions, and every one of these assumptions is wrong . . ." (Lewis 1985, 6).

## Education for Sustainable Development

### Historical Context

Although environmental education continued to expand through the 1980s (Tilbury 1995), the roots for ESD were also forming. The idea of "sustainability" was initially raised in the World Conservation Strategy in 1980 (IUCN 1980). In 1987, the World Commission on Environment and Development (WCED; or Brundtland Commission) issued its report on the relationships between the environment and development and firmly established sustainable development as a focal point for research and practice. Five years later, the UN Conference on Environment and Development (Earth Summit) report, Agenda 21, included a strong focus on education, awareness, and training. The text stated that a key program area for realizing the established goals included "Reorienting education towards sustainable development" (UN 1992, 320). In 1997, the Declaration of the International Conference on Environment and Society: Education and Public Awareness for Sustainability (the Thessaloniki Declaration) noted that the recommendations included in the Belgrade Charter, the Tbilisi Declaration, as well as subsequent statements from environmental education meetings in Moscow (1987) and Toronto (1992) had not been fully explored (UNESCO 1997). The implication was that environmental education, as it had been framed and implemented, had not succeeded and that a new emphasis on sustainable development was appropriate. The Thessaloniki Declaration, as with many early academic reports on the subject, portrayed ESD as part of or the next phase of environmental education.

In the first decade of the twenty-first century, some existing journals and conferences adapted their foci to embrace ESD. For example, the European-based *Journal of Teacher Education and Training* was renamed the *Journal of Teacher Education for Sustainability* and the International Conference on Environmental Education became the International Conference on Environmental Education and Sustainability. The World Environmental Education Congress, first held in 2003, limits its name to environmental education, but does include sustainability in its purpose, suggesting a sense of interchangeability among these terms and concepts. Also in 2003, the Foundation for Environmental Education signed a memorandum of understanding with UNEP, creating a specific focus on education for sustainable development. Additionally, in 2005, the UN declared its Decade of Education for Sustainable Development "to integrate the principles, values and practices of sustainable development into all aspects of education and learning, in order to address the social, economic, cultural and environmental issues we face in the 21st century" (UN 2005, np).

Although other journals had included material relevant to ESD, the first journal clearly titled as being dedicated to ESD was established in 2007. Before that, education for sustainable development had created a specialized niche focused on the role that higher education can play in promoting sustainability. In 2000, the *International Journal for Sustainability in Higher Education* was established, and in 2001, the Education for Sustainability Western Network was established, which eventually morphed into the Association for the Advancement of Sustainability in Higher Education.

### Emphasis

Public attention to environmental concerns heightened in the 1980s (Tilbury 1995), and, simultaneously, there was increasing attention to social justice issues within an international context. Therefore, the idea of "sustainable development" was presented as an attempt to address human needs while considering environmental concerns (WCED 1987). In outlining the need for, and potential approaches to, sustainable development, the Brundtland Commission report included education as a necessary element. Agenda 21 included the following explicit thrusts for ESD:

- Improving access to quality basic education
- Reorienting existing education to address sustainability
- Increasing public understanding and awareness of sustainability
- Providing training for all sectors of the economy.

It is important to note that ESD focuses not just on teaching people about sustainability, but also seeks to ensure basic education more generally as key to achieving sustainable development. The ESD format includes formal, school-based programs for students of all ages, as well as informal efforts targeting the general public.

Definitions of education for sustainable development tend to refer back to the root concept of sustainable development. For example, McKeown and Hopkins (2003) note that ESD is a tool for achieving sustainable development. Though innumerable definitions of sustainable development exist, the most commonly noted is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, 43). More specifically, in establishing the Decade for Education for Sustainable Development, the UN stated that, "Education for Sustainable Development means including key sustainable development issues into teaching and learning; for example, climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption" (UN 2005, np).

Although early environmental education literature clearly linked human and natural systems, the perceived emphasis was on protecting and/or preserving the environment. Sustainable development, on the other hand, very clearly promotes the idea that human needs are paramount and that environmental issues must be considered in concert with economic and human development. This difference in emphasis is a key driver in

the academic discussions that reject the tendency to conflate environmental education and education for sustainable development (McKeown and Hopkins 2003, 2007; Sarabhai 2007; Marcinkowski 2010).

## Industrial Ecology Education

### Historical Context

Unlike environmental education and education for sustainability, no journal is dedicated to industrial ecology education. There has not been a conference on industrial ecology education. Wikipedia does not have an entry with this heading.

Reviewing the historical context of industrial ecology offers insight into its different approach to education. As with the environmental and sustainability movements, industrial ecology has deep roots. Although the article, “Strategies for Manufacturing,” by Frosch and Gallopoulos (1989) is often attributed with catalyzing contemporary interest in industrial ecology, the phrase itself dates to at least the 1940s (Renner 1947). Additionally, some key concepts within industrial ecology have even deeper roots. For example, Henry Ford employed the idea of “no waste” or “closed loops” as he used wooden parts of his automobiles to construct packing crates for other parts, designed automobiles to burn ethanol so farmers could grow their own fuel, and developed Kingsford Charcoal (originally named Ford Charcoal) to not waste the sawdust generated in production facilities.<sup>1</sup> Ford was, perhaps, familiar with Hubbard’s (1902) treatise on utilizing wood waste as an economic necessity for producers.

The variety of fora linking the words “industrial” and “ecology” reflect convergent evolution of an understanding that ecological processes and industrial society are interconnected. Google’s N-gram viewer shows a steep spike in the use of the term ecology in publishing between 1960 and the late 1970s (Google 2013). As the term gained popularity, it was applied in numerous contexts, including references to industrial ecology to describe the social and behavioral aspects of industrial management (Barnard 1963). In 1965, Abel Wolman presented his ideas on the “metabolism of cities” using an ecological metaphor to consider how cities use resources and process waste (Wolman 1965). Even earlier references to industrial ecology applied the idea of ecology to explain industry’s physical relationship to its resource needs and relationships among industrial producers. This invoked the idea and phrase “industrial symbiosis” (see Renner 1947; Calder 1960). Desrochers (2002) provides European examples of “industrial symbiosis” in practice, if not name, dating back to the nineteenth century.

Erkman (1997) provides an historical overview of the term industrial ecology. He highlights significant efforts in Japan, beginning in the 1960s, to shift the economy from resource intensive to one based on “information and knowledge” and a 1983 work that attempted to represent the Belgian economy “in terms of materials and energy flows rather than the traditional, abstract monetary units” (Erkman 1997, 3). By 1989, perhaps because it came on the heels of the Brundtland Commission

report on sustainable development, the timing was right for Frosch and Gallopoulos (1989) to prompt significant interest in industrial ecology. Within a decade, there were conferences, a professional journal, and the beginnings of a professional organization established under the heading of industrial ecology.

Although it did not become an independent focus, education has not been ignored as industrial ecology has established itself. A 1992 National Academy of Sciences colloquium about industrial ecology featured several presentations focused on education (Lynch and Hutchinson 1992; Starr 1992; Troxell 1992). Additional literature has described industrial ecology-relevant courses and degree programs (Cooper and Fava 1999, 2000; Cushman-Roisin et al. 1999; Marstrander et al. 1999; Shi et al. 2003; Allenby et al. 2007; Cervantes 2007; Ning et al. 2007; Biswas 2012). The ISIE includes education as part of its mission, and education is a focal topic for the *Journal of Industrial Ecology*. As noted in the *Introduction*, universities throughout the world offer numerous courses and degrees with an industrial ecology focus.

### Emphasis

As already established, there is no focused track for industrial ecology education; hence, there is no clear emphasis or mission related to such efforts. Assessing how industrial ecology has been defined and its emphases does perhaps provide some insight into why education has not arisen as a dedicated line of inquiry.

Industrial ecology has been defined in multiple ways, including Graedel and Allenby’s (1995) succinct and oft-cited idea that it is the “science of sustainability.” In 2006, Gallopoulos wrote that industrial ecology is a “young discipline that considers industrial and commercial enterprises as an ecosystem analogous to biological ecosystems. Its organising principle is that industrial systems should emulate the best features of biological ecosystems, thereby reducing energy and material consumption and waste generation” (Gallopoulos 2006, 10). In its guide for authors, this journal states that, “Industrial ecology is a rapidly growing field that systematically examines local, regional, and global materials, and energy flows in products, processes, industrial sectors, and economies. It focuses on the potential role of industry in reducing environmental burdens throughout the product life cycle from the extraction of raw materials, to the production of goods, to the use of those goods and to the management of the resulting wastes.”

As the phrase implies and these definitions highlight, industrial ecology is focused on the relationship between industrial processes and practices and the environment; it is focused on industry specifically and industrial society more generally. Academic programs about industrial ecology education have targeted university students with formal, academic programs and training for individuals within industrial settings. These efforts began primarily as an applied approach within technical fields. In reviewing education programs with an industrial ecology focus, Cockerill (2004) found the majority housed in engineering or other technical programs and departments. This, however, does not mean that there

**Table 2** Emphases, format, and target audiences for environmental education, education for sustainable development, and industrial ecology education

	<i>Environmental education</i>	<i>Education for sustainable development</i>	<i>Industrial ecology education</i>
Emphases	<ul style="list-style-type: none"> <li>• Biophysical environment (“nature”)</li> <li>• Human/nonhuman system connections</li> <li>• Promote positive change in environmental conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Basic education + sustainable development principles</li> <li>• Human/nonhuman system connections</li> <li>• Promote positive change for human prosperity</li> </ul>	<ul style="list-style-type: none"> <li>• Concepts/tools to address environmental concerns/meet sustainability goals</li> <li>• Human/nonhuman system connections</li> <li>• Promote positive change in industrial processes/industrial society</li> </ul>
Target format/audience	<ul style="list-style-type: none"> <li>• Formal + informal</li> <li>• K to 16 students + general public</li> </ul>	<ul style="list-style-type: none"> <li>• Formal + informal</li> <li>• K to 16 students + general public + practitioners</li> </ul>	<ul style="list-style-type: none"> <li>• Formal + applied</li> <li>• University students + practitioners</li> </ul>

is uniformity among educational efforts. Though there is an emphasis on technical approaches, Cockerill (2004) identified degrees featuring industrial ecology offered under a diverse array of disciplinary headings, including business, policy, and environmental science. Additionally, whether in engineering or other disciplinary fields, the education-based literature highlights diverse approaches, including emphasizing life cycle assessment (LCA), metabolism, symbiosis, or other focused topics as the core of industrial ecology.

### Discussion: Comparison

Clearly, environmental education, education for sustainable development, and efforts focused on industrial ecology education share common characteristics and ideas. All are products of the historical context into which they arose, and all are dedicated to promoting change to alleviate negative conditions. All feature diverse perspectives in their philosophy and methods. Perhaps most important, all are interdisciplinary and highlight connections among human and nonhuman systems. These similarities are reflected in the numerous overlaps in their historical timing and their emphases. Because environmental education was well established when the idea of sustainable development came to the fore, education was already perceived as important and was embraced as part of the sustainable development agenda. As industrial ecology came into its contemporary form, it was framed as an applied method to address environmental concerns and promote sustainability. See table 2 for a summary comparison of the emphases for environmental education, education for sustainable development, and industrial ecology education.

Equally clear, these three concepts are different, and whereas they share many common roots, each has also developed its own unique form. As the complexities inherent in the connections among human and nonhuman systems have become more apparent, perceived core problems have changed and, subsequently, expectations for what will address these problems has changed. As already described, there was a naïveté

about ecosystems and people surrounding the development of environmental education, which assumed that we understood environmental issues and that providing environmental information to students and the general public would directly lead to improved environmental conditions. As this rosy perception faded and researchers, decision makers, and educators developed a deeper appreciation for the complexity in human and nonhuman systems, this may have contributed to a perceived need for a new approach to education focused on sustainability and an emphasis on basic education as key to meeting human needs. Contemporary industrial ecology arose as an applied approach to address environmental concerns and meet sustainability goals within industrial society. Rather than create a new field of industrial ecology education, industrial ecology principles and tools were initially introduced into existing disciplinary frameworks within higher education and into training programs for practitioners. Later, entire curricula were developed focused on industrial ecology. This different approach to education likely stems from multiple causes, including that environmental education and education for sustainable development were already well established, yet environmental conditions remained a concern and fears about the unsustainable nature of modern society continued to mount. Additionally, initiating industrial ecology education within existing disciplines fit well with the specific emphasis on industry and its applied needs.

In a 2002 editorial in this journal, Helge Brattebø encouraged readers to continue developing courses and programs to teach industrial ecology. He noted, “If we are serious in our wish that IE should influence society tomorrow, we have to teach it seriously today” (Brattebø 2002, 2). The number of industrial ecology courses and degrees existing today suggests that his message has been heeded. Yet, industrial ecology education remains decentralized. O’Rourke and colleagues (1996) concluded that this is true of industrial ecology itself, that it lacks a unified theoretical construction and hence, perhaps, a clear identity. What and who is included within the industrial ecology framework is not well established. Industrial ecology encompasses a diverse array of tools and concepts, including LCA, material flow analysis, and industrial symbiosis. Yet, not

all individuals who teach these concepts consider themselves industrial ecologists and this limits where and how industrial ecology is presented. Some researchers conflate a specific tool with the entirety of industrial ecology. This is evident when reading papers that purport to be about industrial ecology education, but are focused specifically on teaching LCA or industrial symbiosis (as examples) with no recognition that these are single concepts within a broader context of industrial ecology. As Brattebø (2002) concluded, industrial ecology is a “flexible concept,” which has undoubtedly contributed to the lack of a formalized approach to education.

While seeking pedagogically driven material about industrial ecology education in 2012, I spoke with numerous scholars who do teach industrial-ecology-relevant material. These interviews revealed a strong focus on teaching how to apply industrial ecology tools and principles in practice, but much less interest in exploring education about these concepts and tools more generally. Several of these scholars expressed a pragmatic rationale for this in noting that pedagogical research or publishing about their teaching is not rewarded and therefore it is not pursued. Although substantiating it is beyond the scope of this article, the departments and disciplines where industrial ecology practitioners reside, compared to environmental education or ESD practitioners, may influence how scholarship about education is received and subsequently affect conditions needed to develop a focused concentration on education. The lack of pedagogical interest may also reflect a sense that the broad educational approaches for environmental and sustainability efforts were less effective than had been hoped, and therefore educating within existing disciplines makes more sense, especially for such an applied field as industrial ecology.

Regarding education (and perhaps industrial ecology generally), this decentralized approach may be a strength, not a weakness. If industrial ecology were universally defined and therefore contained, it could lose much of its ability to positively affect industrial systems. The power of industrial ecology, and hence education about industrial ecology, may lie in its ability to be applied both within existing industrial processes and also in ways not yet anticipated and certainly not proscribed. As researchers, educators, and practitioners teach industrial ecology within their traditional disciplinary areas or within multidisciplinary settings, it advances the concept of industrial ecology broadly while maintaining a necessary focus on ensuring sound disciplinary education. Industrial society needs engineers, chemists, accountants, and planners with their requisite knowledge and skills. Therefore, inculcating industrial ecology into these required fields may more rapidly transform current practice than any overarching approach to industrial ecology education. When these engineers, chemists, accountants, and planners enter the workplace, and begin to engage with others who have learned about industrial ecology from differing perspectives, it may give them a starting point for expanding when and how industrial ecology is applied. Of course, this approach also has the potential to raise contention among those with disparate understandings of industrial ecology. The benefits of spreading the word widely, however, would seem

to outweigh any potential constraint offered by the flexible, decentralized approach to industrial ecology education.

What may be more problematic than a lack of a formalized, generalized industrial ecology education is that industrial ecology is not well represented within either the environmental education or the ESD literature. A search for the phrase industrial ecology within leading environmental education and ESD journals found 49 “hits” that represent only four articles and two book reviews. Leal Filho (2002) includes sustainability as part of environmental education in exploring ideas for integrating industrial ecology concepts into environmental education. He discusses the idea that environmental education is largely focused on changing attitudes and behaviors, whereas industrial ecology is more directly applied to changing how industry functions. He also notes that industry has long been perceived negatively and as the cause of many environmental problems. Therefore, there is an immediate disconnect between the philosophy inherent in environmental education and that in industrial ecology. Erkman (1997) also recognized this in noting that industrial ecology is often perceived as an oxymoron. These differences have undoubtedly influenced how education related to these concepts has evolved and why industrial ecology remains underrepresented in the environmental education and ESD literature. This provides tremendous opportunity for any scholar who does wish to focus on advancing and expanding education about industrial ecology. As Leal Filho (2002) discusses, better integrating these fields is possible, and continuing to identify and seek ways to place industrial ecology within environmental education and/or education for sustainable development may be a productive avenue for scholarship and action.

## Conclusion

Environmental education, education for sustainable development, and efforts in industrial ecology education all reflect the context of their roots and present similarities and differences in their guiding philosophies. Environmental education arose during the social upheavals and grassroots idealism of the 1960s and 1970s, which often reflected romantic-era ideals about nature and people. It also reflected a simplistic understanding of environmental issues, concluding that if people were educated about the environment, then addressing environmental issues would be straightforward. By the 1980s, concerns about equity and justice internationally were being coupled with concerns about the human relationship to the physical environment. This prompted attention to education for sustainable development, which emphasized a necessity for people to be educated in a basic way, as well as to be educated about sustainability. Industrial ecology arose as an applied attempt to address environmental concerns and meet sustainability goals. It has developed into a diverse, multifaceted approach to addressing the complexity inherent in industrial society. Education focused on industrial ecology can be characterized by its decentralized approach, with traditional disciplines integrating core principles and tools into their programs, as well as development of

industrial-ecology-specific curricula. These efforts have not coalesced into a formalized, industrial ecology education. Rather than reflecting a shortcoming, this potentially offers a more robust method for realizing widespread application of industrial ecology throughout industrial society. Better integrating industrial ecology into the well-established environmental education and ESD literature and practice would contribute to more thorough access to industrial ecology principles and tools, and this is a research area ripe for more attention.

## Note

1. This information was presented in a keynote address by a historian at the Henry Ford Museum during the 2003 meeting of the International Society for Industrial Ecology.

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