
Towards a closer integration of environmental education and industrial ecology

Walter Leal Filho

Technical University Hamburg-Harburg, Environmental Technology,
D-21073 Hamburg, Germany
E-mail: leal@tu-harburg.de

Abstract: Industrial processes are known to have different levels of impact on the environment and, as a result, there is a need to foster knowledge of the environmental consequences of industrial activities and check those against their benefits. One of the ways of achieving this is by applying the concepts of industrial ecology to industry's day-to-day life. Another possible way of pursuing this goal is by using environmental education as a tool towards increasing awareness with regard to the social, political and economic relevance of, as well as the need for environmentally sound industrial activities. On the basis of the need for more specific literature addressing the particularities of the links between industrial ecology and environmental education, this paper outlines the common features of both subjects, provides examples of contexts when such approaches may be integrated and describes the need for more integrated approaches.

Keywords: Environmental education; industrial ecology; training; environmental quality.

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Biographical notes: Professor Walter Leal Filho teaches environmental management at the Royal Institute of Technology in Stockholm, Sweden and at the Technical University Hamburg-Harburg in Germany.

1 Introduction: contextualising industrial ecology and environmental education

There have been various attempts to define both industrial ecology and environmental education and to outline their various remits and limitations. Industrial ecology, whose definition is provided in the *White Paper on Sustainable Development and Industrial Ecology*, issued by the Institute of Electrical and Electronic Engineers and quoted in Allenby [1], "is the objective, multidisciplinary study of industrial and economic systems and their linkages with fundamental natural systems".

A complete view of industrial ecology would therefore be likely to include the wide range of activities which are part of industry, including in this line of thinking,

manufacturing, production and services, all of which, it should not be forgotten, have an impact on the environment.

Perhaps one of the first successful attempts to describe the particularities of industrial ecological concepts was made by Frosch and Gallopoulos [2] who, in 'Strategies for Manufacturing' describe some of the major issues that outline industrial ecology. Also, a historical review of industrial ecology, made by Erkman [3], offers interesting insights into its evolution while critical appraisals such as those performed by Young and Sachs [4], Ayres and Ayres [5] and Porter and van der Linde [6] indicate that, far from being a simple matter, the inclusion of an ecological dimension within industry - albeit feasible - is not a simple task and many variables need consideration. In this context, works by Allenby and Deanna [7] on the greening of industrial ecosystems, Lowen, Warren and Moran [8] on the components of industrial ecology and O'Rourke, Connelly and Koshland [9], which have critically looked at its elements, provide important contributions towards clarifying what it can and cannot do.

The literature also offers a fairly comprehensive set of analyses on the subject matter of industrial ecology, which includes works by Duchin [10] on the economics and social aspects of industrial ecology, the book by Ayres and Simonis [11] on industrial metabolism and Coté and Ashford's [12] wide-ranging papers amassed as part of the special issue of *The Journal of Cleaner Production*. The documentation arising from events held as early as ten years ago such as the proceedings of the first conference on industrial ecology, sponsored by the National Academy of Engineering, edited by Ausubel and Sladovich [13], which includes articles on industrial metabolism, dematerialisation, energy, economic implications, and educational challenges, also provides a useful basis to the understanding of the various applications of industrial ecology.

Socolow, *et al.*[14] have, in *Industrial Ecology and Global Change* described how humankind can continue to industrialise without disrupting and destroying natural ecological systems, being directed toward readers who have the desire to participate in effectively implementing appropriate strategies. Its five main sessions debate issues such as:

- 1 the industrialisation of society
- 2 the main natural systems cycles
- 3 toxic chemicals in the environment
- 4 industrial ecology in firms and finally
- 5 policy making in the context of industrial ecology.

This, at the same time as dealing with important themes such as the use of solar energy, recycling, the need for innovation at industrial level, does not forget to include some international perspectives.

Environmental education, in its turn, has a slightly longer tradition. In fact, the development of environmental education over the past 20 years has been remarkable [15]. Originally defined by the World Conservation Union (IUCN) as a process targeted towards clarifying values and fostering positive attitudes towards the environment - drawing attention at the same time to the inter-connection of environmental processes - [16], environmental education has evolved from a mere term aimed at giving insights into

the need for educating people for, about and through the environment, to an expression which describes a process regarded as effective in fostering a better relationship between human beings and the surrounding environment and which has as its ultimate goal the development of sustainable habits and behaviours [17].

The development of environmental education has not been easy and has been aggravated by past, present and no doubt future adversities. In addition to the usual problems related to when, how and where to undertake environmental education projects, programs and other initiatives, there is a pool of social, political and economic issues that integrate the process and which have in the past – due to a lack of appreciation of the subtle structural and functional relationships between itself and the above-mentioned social, political and economic factors - been largely overlooked.

As documented by Keiny and Zoller [18] “environmental education became a label for diverse, innovative educational trends.” This state of affairs was especially conspicuous during the 1970s, when environmental education was often associated with field studies or outdoor studies. Later on, it was considered as an item which should be seen in school teaching [19] with two major events dedicated to an in-depth discussion on the various factors involved [20,21]. Finally, more recently, over the late 1980s and early 1990s, environmental education has been largely considered as a being a ‘cross-curricular theme’ which needs to be implemented (or ‘diffused’ as some would say) in the curriculum and out of it, thus contributing to the environmental literacy of the world’s population [22]. Attempts have been made since to document environmental education initiatives systematically [23,24] and to review the impact of previous events [25].

Today, ‘modern’ environmental education deals with matters such as lifelong learning [26], sustainability [27] and international dynamics [28], i.e. contexts other than formal teaching. This is a step forward when compared with its past focus, which has made it of interest to few people and relatively innocuous from a political perspective.

Despite their different roots and profiles, there has to be acknowledged the existence of a number of common features related to the methods and approaches through which industrial ecology and environmental education may be pursued. The analysis of such common features may be helpful towards a better understanding of environmental issues and in solving environmental problems. After all, their basic goal is the same: to contribute towards a better man-environment relationship and towards improving the quality of life.

2 The contribution of industrial ecology and environmental education to sustainable development

As seen in Graedel and Allenby’s book [29], industrial ecology is still in a formative stage, with a diversity of definitions and understandings of scope of application. A certain degree of consensus seems to be emerging around certain key themes. For example, in the development of eco-industrial parks [30,8,31,32] significant progress can be seen. Moreover, the applications of industrial ecology to specific sectors such as transport has evolved a great deal since Frosch and Gallopoulos’ ‘Strategies for manufacturing’ [2] to the point that it provides specific measures, directly relevant for the automobile sector [33].

However, there are still some areas of divergence among industrial ecologists. According to the opinion expressed by various authors, the majority of discussions of industrial ecology tend to agree on the following elements.

- industrial ecology is a systems approach drawing upon methods for analysis and synthesis from systems science
- it seeks to redesign industrial activities to reduce the ecological impact of human activity to levels natural systems can sustain
- it is interdisciplinary, linking the research and planning of many fields, including ecology, engineering, economics, business management, and public administration and law, among others
- it studies the flows of materials and energy through the economy, ranging from those of an industrial or public facility to the planet itself and seeks strategies to increase the efficiency and reduce the impact of these flows
- it enables local decision making with awareness of broader regional and global impacts.

The above points of discussion show a close relationship between what industrial ecology strives to achieve and the goals set out in documents such as *Our Common Future* [34], which emphasises the contribution of sound environmental policies within industry, as a means of achieving the goal of sustainable development. The publication, also known as the *Brundtland Report* defines 'sustainable development' as development that meets the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- 1 the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given and
- 2 the idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs.

Both items are of interest to industrial ecology, although emphasis is often given to the latter. There are many within the industrial ecology community who defend the view that industrial ecology is a means of balancing environmental protection with economic and business viability [35]. This balance, it is often argued, must be dynamic, adapting to new knowledge about industry's impacts and nature's responses.

Concern about the relationships between industrial ecology and sustainable development is easy to spot. Graedel and Allenby [29], in what is probably one of the first university textbooks on industrial ecology, offer a broad overview of the environmental concerns generated by industry's impact on natural systems ranging from global to local scales, having sustainability in the background. In terms of methodology, the book focuses on lifecycle assessment and design for the environment, giving a very detailed description of the matrix approaches developed by these authors. The text concludes with forward-looking topics, including organisational opportunities and constraints, standards, and new enabling technologies. In addition, Hall and Cleveland [36], in *Energy and Resource Quality: The Ecology of the Economic Process* outline the meaning of the expression 'industrial ecosystems', and the concept of industrial ecology as it is related to economics and as it hooks up with sustainability.

It is clear that, in order to be effective and in line with the principles of sustainability, industrial ecology needs to interact with other fields such as ecological economics and environmental accounting, in creating the foundation for sustainable development. This can be achieved by:

- 1 searching for ways of minimising the environmental consequences of industrial activities
- 2 trying to focus on industrial activities from a cradle to grave perspective, i.e. from the purchase of components to the end product
- 3 fostering links between industrial processes per se and environmental conservation and social process initiatives.

Some areas of criticism of the concept of industrial ecology as it relates to environmental education per se and the long-term goal of sustainable development are:

- the search for solutions to environmental problems sometimes ignore the magnitude of social and political concerns
- the usually short-term goals of industry sometimes prevent the implementation of measures leading to longer-term benefits, solutions with immediate impacts being preferred.

Some ways of addressing such problems are described further on in this paper.

Similar to what is seen in relation to human ecology, the contribution of environmental education to sustainability is also significant. Its goals, as defined in the Belgrade Charter, published after the 1975 UNESCO Conference held in the capital of the Republic of Yugoslavia, are:

- 1 Awareness: to help individuals and social groups acquire an awareness of a sensitivity towards the total environment and its allied problems.
- 2 Knowledge: to help individuals and social groups acquire a basic understanding of the total environment, its associated problems and humanity's critically responsible presence and role in it.
- 3 Attitude: to help individuals and social groups acquire social values, strong feelings of concern for the environment and the motivation to participate actively in its protection and improvement.
- 4 Skills: to help individuals and social groups acquire the skills for solving environmental problems.
- 5 Evaluation Ability: to help individuals and social groups evaluate environmental measures and education programs in terms of ecological, political, economic, social, aesthetic and educational factors.
- 6 Participation: to help individuals and social groups develop a sense of responsibility and urgency regarding environmental problems to ensure appropriate action to solve these problems [20].

The Belgrade Charter also set out the guiding principles of environmental education. It maintained that environmental education should:

- 1 Consider the environment in its totality – natural and manmade, ecological, political, economic, technological, social, legislative, cultural and aesthetic.
- 2 Be a continuous lifelong process.
- 3 Be interdisciplinary in approach.
- 4 Emphasise active participation in preventing and solving environmental problems.
- 5 Examine major environmental issues from a world perspective.
- 6 Focus on current and future environmental situations.
- 7 Examine all development and growth from an environmental perspective.
- 8 Promote the value and necessity of local, national and international cooperation in the solution of environmental problems [20].

From the above list it can be inferred that the focus on raising environmental awareness and the emphasis given to formal and informal teaching (without which it may alienate itself from mainstream environmental conservation) are two of the strongest points of environmental education. It illustrates at the same time some of the contributions it can offer to industrial ecology.

3 Benefits gained from common approaches

If one compares some of the perspectives provided by industrial ecology, as described by Socolow and quoted by Allenby [1], with some of the perspectives by environmental education, a number of interesting similarities can be seen, as illustrated in Table 1.

Table 1 Perspectives in industrial ecology and environmental education

<i>Industrial Ecology</i>	<i>Environmental Education</i>
focus on long-term approaches	is a long-term process and entails long-term results
focus on concerns of regional and global scope	its concerns encompass local, as well as regional and global issues
focus on cases where human activities overwhelm natural systems	has a preventive as well as a curative dimension also trying to prevent ecosystems from being overwhelmed
attempts to understand and protect the resilience of natural and human systems	focus on raising awareness and motivation towards environmental protection, focusing on man's role
uses systems techniques as mass-flow analysis to understand economic and environmental systems	uses role-play, scenery building and hands-on approaches to help to understand environmental issues and problems
views economic production agents as central to mitigating environmental impacts and seeks to understand how to make them more environmentally friendly	sees economic phenomena and political and social contexts as influencing environmental dynamics and seeks to integrate them in the environmental problem solving process

In addition, some further common features of industrial ecology and environmental education reside in the fact that both are:

- interdisciplinary: both areas cannot be effectively be worked out without the body of knowledge from related fields such as ecology (per se), economics, mathematics, sociology, etc.
- integrative: both areas try to encompass information deriving from different sources, from different fields, which they then assimilate and integrate as part of their own profile.
- focus on sustainability: no matter the angle one looks at in both areas, their ultimate focus is the search for ways through which sustainability may be pursued.
- participatory: industrial ecology and environmental education rely on the active input of individuals in pursuing their goals and aims and in their participation in influencing ever-changing scenarios.

Last but not least, both are continuously going through a process of change. Such a change, albeit not always dramatic, is indeed a common element of both areas and enables them to evolve along within society, as society itself is going through its own changes.

In addition, the areas where the different approaches are mutually complementary may include four main domains: the views adopted, the objectives, the approach used and their target groups. Let us look at each item in turn:

- 1 *The views adopted:* industrial ecology looks at things from a critical, systemic perspective, angles which environmental education tends to ignore. On the other hand, environmental education sees environmental matters as globally interconnected, where the three 'Hs' (heart, head and hands) provide a combined input to the understanding of nature.
- 2 *The objectives:* strictly speaking, a main concerns of industrial ecology is the integration of environmental considerations into industrial activity, paying attention to economic aspects. Environmental education seeks to foster awareness on environmental matters and as a result, catalyse active participation in environmental action.
- 3 *The approach used:* industrial ecology works intensively via incremental improvements in environmental management with a view to improving the efficiency of industrial activities. Environmental education, in its turn, tries to develop a sense of commitment towards the environment and prevent the exacerbation of environmental problems by working at the conscience level.
- 4 *Target groups:* industrial ecology will primarily focus on those whose activities are directly related to industrial practice, while environmental education - be it performed in formal or informal teaching - aims at *all* individuals since it works on the assumption that every person has an impact on the environment.

Industrial ecology may be seen as a combination of a scientific field and a sector where environmentally sound processes may be tested and implemented [37,38]. Environmental education is often seen as a process by which educational approaches and methods are put to use in order to raise better awareness on environmental matters. It focuses on soil,

water, air, plant and animal life, forests and other ecosystems. It incorporates not only education per se, but also, land-use planning, the concept of shared decision making, and the use of information systems. Environmental education also addresses renewable and non-renewable natural resource use in urban and rural settings. It involves people, communities, and organisations in experiences that apply appropriate technology to everyday problems. Reliance on scientific methods and principles enables educators to deliver objective information, even if issues are emotionally charged. This illustrates how complementary both areas are and the usefulness of approaches aimed at integrating them.

The goal of integration can be achieved by various ways, such as:

- 1 via the design of projects where attention to both matters are paid
- 2 via case studies in which industrial ecology is combined with educational approaches such as, for example, industry-based environmentally-focused training programs
- 3 by means of projects in which the development of analytical skills is combined with environmental problem solving efforts
- 4 by developing competence among staff working in industry in relation to environmental dialogues so as to enable them to deal with the public
- 5 by integrating principles of environmental communication and information as part of the normal business practice in industry.

Since the degree of development of industrial ecology among countries varies and so does environmental education's [39], the choice of which approach to use and the extent to which a certain area is favoured – as opposed to others - may vary according to local contexts.

An interesting case study of how integration may be achieved is offered in the handbook *Eco-Industrial Parks* [38]. The handbook considers many strategies for community sustainable development as a context for industrial park development or renewal, where educational approaches are implicit. It ranges from the soft infrastructure of policy, finance economic development, and education aimed at meeting the specific technical, recruitment, and management considerations in industrial park design. The handbook also supports community teams working on sustainable economic development strategies and redevelopment of brownfield sites as well as the design and development of new eco-industrial parks. Much of the thinking in this publication translates readily to the design and management of public facilities and infrastructure. In the case study, a broad range of industrial, economic development, environmental, and government players in the early phase of forming a strategy for a local eco-industrial park were supported. It demonstrates the effectiveness of integrated approaches to industrial ecology.

4 Addressing some problems

There are of course some particularities which not only limit the fields of action of environmental education and industrial ecology but may also – potentially - restrict joint applications. First of all, the focus of industrial ecology is obviously the industrial sector,

while environmental education is much broader (although it also encompasses industrial activities). Second, there is a natural inclination of environmental education to concentrate on formal teaching. This is because, in this area, the 'educationalists' (professionals of the environmental education sector with an educational background) exist in far greater numbers than the 'environmentalists' (those with a background in ecological or natural sciences). In addition, changes in the field of environmental education are progressive (and, as such, slow), focusing on improvements in attitudes and behaviours over a period of years or decades. Industrial ecology, due to its own nature, works on shorter time spans.

Another problem to be addressed in moves towards the closer integration of industrial ecology and environmental education is the issue of perception. Traditional environmental educators go a long way towards avoiding specific reference to industry-related issues out of sheer ignorance about details related to them. Historically, industry has always been seen as a negative entity, the cause of various environmental problems and the root of all sorts of ailments to both people and the physical environment. Industrial ecology, already closer to the hearts of environmentalists due to the suffix 'ecology', tend to see environmental matters under very specific angles, being bound to be problem-oriented, without always paying attention to the benefits awareness-raising components may bring about. Other perceptual problems are:

- the technicalities of industrial ecology (e.g. management, production) are seen as too complex for educators
- the principles of education and pedagogy (e.g. motivation, awareness-raising techniques, role-play) are judged as too vague by industrialists
- the lack of tradition of joint ventures between the two sectors
- the nature of education which, as a process, only produces results in the medium and long term, while in the industrial sector, emphasis is given to immediate results.

A question to be asked is, if the integration of both areas is so positive, how can these problems be addressed in a meaningful way?

The answer to this question is not simple, but goes to the heart of environmental issues themselves. There is no disputing the fact that the quality of our environment - the air we breathe, the water we drink, the natural resources we require - is important to everyone. Yet responsible citizens know that we cannot take environmental quality for granted. In the same measure, responsible industrialists know that although some degree of tolerance in relation to the environmental consequences of their activities may be found, they will not be allowed to cause unreasonable damage to the environment. Few would dispute the fact that, in the context of industrial activities, emissions and wastes should be reduced and recycling should be practised. Yet, prior to making such items a reality, there is a need for the re-orientation of industrial activities towards more ecologically-acceptable standards, a goal industrial ecology aims to pursue. It is here where the heart of the problem lies: the need to differentiate industrial ecology from industrial activities per se and emphasise its 'good' environmental side.

Industrial ecology and environmental education may also be integrated by focusing on issues of global concern, such as:

- Air, land, and water quality.
- Citizen understanding and responsibility for public policy and environmental justice.
- Conflict management and other social-process skills.
- Ecologically sensitive approaches to land use.
- Ecosystem management, biodiversity, and threatened and endangered species protection.
- Energy alternatives/conservation.
- Environmental hazards, risks, and liability minimisation.
- Human interaction with natural resources and ecosystems.
- Integrated resource management.
- Pollution prevention/clean-up.
- Solid, hazardous, and animal waste management.
- Sustainable production and efficient use of goods and services from natural resources.

But they need to do that, not from their separate industrial or merely pedagogical angles, as has largely been the case so far, but in an *integrated* way.

5 Conclusions

As the 21st century begins, world attention is focused on how to make sure the environment and natural resources are sustainably used. Global trends and concerns are often expressed through community level actions. However, policy makers and industrialists in urban and rural communities are the ones making most decisions about the use of energy and forest products, which, if not carefully taken, invariably lead to problems such as overflowing landfills or poor air quality, to name but a few. Industrialists and educators alike want to protect wildlife habitats and open space, they want to understand global change and to address dozens of other environmental questions. They can do this better by changing the ways environmental issues are usually handled.

Policy makers' actions, resulting from thousands of decisions, collectively influence the sustainability of our natural resources and our environment. Making intelligent decisions about environmental issues is critical, but it is not always easy. The amount of environmental information available is astounding and includes both fact and fiction. Some experts tend to emphasise the tangible benefits to society through harvesting natural resources. Other sources may highlight environmental health as the only relevant consideration for natural resource management decisions. The most accessible information may not be the most useful and the job of searching for particular knowledge may be overwhelming.

Teaching people how to make intelligent decisions about the use and management of natural resources is our best insurance for sustaining the production of goods and

services, while protecting the natural resources on which we depend. There is a perceived need to help people to acquire the knowledge, skills, and tools they will need to make informed decisions about natural resources and the environment. This also applies to the industrial sector. By integrating industrial ecology with environmental education and other programs, millions of people can learn more about the relationships between natural resources, environmental sustainability, and human well-being. This knowledge, accompanied by appropriate action, is necessary to maintain not only our natural resources, but also our way of life. Industrial ecology and environmental education thus need to reach for closer cooperation and more involvement in expanding their combined effect. With the support afforded by these two areas, industrialists on the one hand and educators on the other, can do more than ever to help people understand - and act on - environmental concerns.

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