Abstract: This research reviews the aptitudes of Japanese industrial designers during the early activities of ecodesign. First, an overview of the major events that occurred in the end of the nineties and were related to industrial design and ecodesign are reviewed. The principle of ecodesign and the activities of industrial designers in relation to environmental concerns are then described. A set of questionnaires formulated based on this information was distributed to industrial designers employed in medium- and large-sized Japanese companies. The results showed that, at the personal level, operational and strategic designers involved (or not) with ecodesign activities demonstrated proactive attitudes in their attempts to identify solutions to current environmental issues. However, as they were employees working in corporate design departments, they tended to be reactive. The typical industrial designer involved with active product development was employed by a company in which a department, or a special group of employees, was responsible for adherence to the environmental policy. Greater participation in ecodesign by industrial designers involved with passive, rather than active, products was noted.

Key words: EcoDesign, Sustainable Design, Eco-product, Design for Environment

1. Introduction
This research reviews the aptitudes of industrial designers towards ecodesign; namely, the personal attitude that industrial designers had concerning environmental issues, their participation and involvement in the environmental product development, and their knowledge of ecodesign principles. The research is focused on the industrial designers employed in Japanese companies during the early activities of ecodesign in Japan at the end of the nineties. First, an overview of major events related to industrial design and ecodesign during this period is provided herein. The principle of ecodesign, its definition, and the different perspectives from experts are then described in addition to the activities of industrial designers in relation to environmental concerns. Based on this information and foreign literature published by experts on ecodesign, a set of questionnaires was formulated and distributed to industrial designers employed in medium and large Japanese companies. According to the results of the questionnaires, industrial designers employed in companies did not significantly participate in the activities of ecodesign. This finding is discussed in the final section of this paper. In the future issues, which the author reviewing chronologically the activities of industrial designers toward ecodesign from nineties until now, discusses the current issues and ways for a possible implementation of the industrial designers skills in environmental product development.

2. Justification for Choosing the Theme, Period, and Japanese Companies
This research is based on the previous studies [1, 2] a part of a doctoral thesis whose review and publication in English language is justified by the lack of reference literature in this language that pertains to industrial designer skills for ecodesign activities and discusses the participation of industrial designers in ecodesign activities in companies, particularly during the early stage of the development of ecoproducts. This fact is noted in the papers published from the International Symposium on Eco Design (Japan) from the years 2003 to 2011 [3-7]. A few papers discuss the industrial designers and their activities on ecodesign from a global perspective. Some references to this subject came from foreign countries, e.g., Netherlands, Sweden, United Kingdom and Germany. Another important aspect of reviewing and publishing research on this subject is that it will serve as a historical reference and point of reflection for future activities to be performed in the field of industrial design with the aim of sustainable production and consumption at the national as well as international level.

Notably, the end of the nineties saw a large growth in
national and international events related to ecodesign in Japan during the period from 1999 to 2001. For example, in 1999, the First International Symposium on Ecodesign was held in Japan [8]. This was the first international academic event to focus on ecodesign, in which researchers from several fields and different countries, industries, and governments discussed issues pertaining to ecodesign and methods to achieve sustainability. Other events were also held in Japan in the same year: “The First Eco-Products Exhibitions 99” and “The First Sustainable Product Design Exhibition 99.” The interaction and cooperation between the government, industries, ONGs, and the general public at the events was remarkable. Owing to their success, these same events were held again in Japan, two years later, in 2001 [9].

The focus on the industrial designers employed in the Japanese companies, particularly those employed in medium- and large-sized companies, was on account of the information published in a special issue of Ecodesign by Design New [10]. The special issue identified Japanese companies that had developed products aimed at addressing environmental concerns. The companies mentioned in this study were considered pioneers and leaders in Japan in the development of products that took environmental aspects into consideration. Another important factor was that Japanese companies were the leaders in the world with ISO 14001, The International Organization for Standardization certifications. At the time that this special issue was published, the number of ISO 14001 registered Japanese products exceeded that of other countries, and in this regard, Japan was followed by Germany, Sweden, and Great Britain. In Japanese companies, the development of products by taking environmental aspects into consideration was very significant. Electrical appliances and consumer electronics formed the majority of the certified products in Japan [11].

3. Research Objectives

As discussed in section 2, Japanese companies were the global leaders in the development of products that took environmental aspects into consideration, and there is a paucity of literature on the ecodesign-related activities of industrial designers. In light of these two factors, the following research objectives have been formulated:

1) How can industrial design be characterized during the early activities of ecodesign at companies in Japan?
2) What is the definition of ecodesign from an academic perspective?
3) What personal attitudes do industrial designers have with regard to environmental issues?
4) How can the attitudes of operational and strategic designers toward environmental product development be characterized during this period?
5) How can the involvement of industrial designers in environmental product development be characterized?
6) How can industrial designers’ knowledge of ecodesign principles be described?
7) What is the best environmental information for industrial designers?

4. Design of Research (Method)

Figure 1. shows the structure of the study and outlines its main objectives. First, the Japanese and foreign literature concerning the ecodesign-related activities of industrial designers in Japan and the principles of ecodesign were reviewed. Based on the theoretical studies related to the role of industrial designers in ecodesign that were conducted by experts [12, 13], the personal attitudes of industrial designers towards environmental issues were classified as proactive and reactive. Industrial designers employed in the companies were classified into strategic designers and operational designers involved in environmental product development. The classifications of strategic and operational designers were based on the research work of Bakker entitled “Environmental Information for Industrial Designers” [14]. Essentially, both strategic and operational designers are involved in different environmental product development activities. Here, it is important to differentiate
between strategic designers involved in product planning (a product or mix of products for development) and operational designers involved in the design stage (anticipated production based on an abstract idea).

The activities of industrial designers employed in the companies were also classified as passive and active, and they were classified according to the category of the environmentally friendly product that industrial designers were engaged in developing. For example, a passive product is a product that does not require energy when being used (textile, stationary goods, furniture, etc.); its impact on the environment during the use phase is minimal. An active product (lighting, machinery, equipment, transportation, etc.), however, is a more complex product that consumes a certain amount of energy during use; its impact on the environment during the use phase is significant.

Based on theoretical studies, a set of questionnaires was formulated and distributed to industrial designers. The basic method and content of the questionnaires were also based on Bakker’s research [14]. The questionnaires were distributed to more than 90 Japanese companies involved in ecodesign.

### 5. Historical Overview of Industrial Design During the Early Activities of Ecodesign in Japan

The concept of sustainable development was introduced in 1987 [15]; however, in the industrial design field, environmental awareness was highlighted in a design competition known as the International Design Competition, Osaka, in which the theme was related to the elements of nature: “Water” (1987), “Fire” (1989), “Terra” (1991), and “Wind” (1993). After the “Earth Summit” held in Rio de Janeiro in 1992, the first national design competition related to environmental issues was held in Japan. The title of the design competition was “Green Designing in Yamagata 1992.” The purpose of the competition was to motivate industrial designers to develop scenarios for the future based on the concept of sustainable development. The Grand Prize was awarded for the design of a Mobile Greenhouse Farm System for producing food under the deck of a ship while utilizing natural resources and organic trash from urban areas. Design competitions related to ecodesign have been held regularly in Japan since this national event was conducted [16].

In 1993, Design News by Japan Industrial Design Promotion Organization (JIDPO) published a special issue with the title “Design Studies for Ecology.” This special issue reported on Japanese companies that had developed products in light of environmental concerns. Ninety Japanese companies and their ecoproducts were showcased along with a description of the details on how they improved the environment [10].

In 1997, Nikkei Design published a special feature focused on the eco-package, showing products from Japanese companies and foreign countries (Germany, France, Switzerland, and Italy) [17]. In the same year, the Japanese Society for the Science of Design (JSSD) published a special issue entitled “The Consideration of the Relationship Between Design and Ecology, Recycle and PL-Law.” In this issue, twelve articles from academic and professional experts presented ecological approaches related to sub-themes, including material, recyclable, waste disposal, and cultural aspects. These case studies highlighted the efforts made in the industrial design field to generate environmentally friendly product concepts [18].

In 1999, the “First International Symposium on Environmentally Conscious Design and Inverse Manufacturing” (EcoDesign ’99) was held in Tokyo [8]. A total of 198 academic papers about environmental issues were presented at this event. From among the various disciplines represented, only five were from the industrial design field. One paper was from Italy; the other four were from Japan. Japanese researchers explored the concepts of eco-packaging, life cycles, and zero emissions based on the region of origin.

At the same Table 1 of the various disciplines represented, were noted for categories of process technologies, elemental technologies, design and life cycle management. Papers from Japan focused on ecomaterials, new materials, and organic waste treatment technology. Foreign papers focused on environmentally conscious design and environmentally conscious design tools. It was noted at this symposium that the studies in ecodesign were classified into several categories with different approaches and in a broad context, based on the sociocultural, economical, and technological aspects. Other events were also held in Japan during the same year: “The First Eco-Products Exhibitions” and “The First Sustainable Product Design Exhibition ’99.” The interaction and cooperation between the government, industries, ONGs, and the general public were remarkable.

In 2000, the Japanese Committee of Ecodesign, supported by The Japan Environmental Management Association for Industry, drafted practical working plans for applying uniform design standards. These plans included publication of the standard ecodesign manual featuring quality function deployment for the environment (DFDE) as a supportive tool and a proposal to promote ecodesign through the establishment of a supporting network [19]. The plans are summarized in Table 2.

In 2001, a recycling law concerning electrical appliances took effect. Japanese companies were facing more public scrutiny and pressure to reduce the environmental impact of their products.

After the success of the “First International Ecodesign,” the “Second International EcoDesign 2001” was also held in Japan. The previous symposium proved the importance of the issues for industries and society, and 269 papers from 23 countries around the world were presented. The number of papers presented at this symposium exceeded the expectations of organizers. This International Ecodesign Symposium continued to be held in the following years: 2003, 2005, 2007, 2009, and 2011. Finally, the historical overview of industrial design during the early activities of ecodesign in Japan was characterized by support of the Japanese government and many of the nation’s companies, as evidenced by numerous events and activities surrounding the introduction of ecodesign from 1999 to 2001.
6. Reviewing the Definition of Ecodesign from an Academic Perspective

In the design field in Japan, the first definition of ecodesign was introduced by Japanese Dictionary of Today’s Design (1992) [20], and examples of products manufactured by Japanese companies that were associated with the keywords “recycle,” “reuse,” and “reduce” were provided. Such products included the first recycled toner for a copy machine, a passive solar home, and the hybrid car. And also the example of idea system concept awarded in the design competition of “Green Designing in Yamagata 1992.”

In 1996, Fiksel [21] described ecodesign as the development of products on the basis of environmental criteria aimed at the reduction of negative environmental impact through the various stages of the product’s life cycle according to the life cycle assessment (LCA). This author advocated approaching ecodesign and environmental design systematically to improve the environmental performance of products and processes over their full life cycles.

In 1999, Manzini [22] described ecodesign as “a design activity aimed at connecting what is technically possible to what is ecologically necessary in order to arouse a socially and culturally acceptable new proposal.” He also stated, “Sustainable society cannot be achieved by improving the environmental redesign of the old product-oriented paradigm. What can be done is to promote an environmental re-orientation of the new information and service paradigm. That is an environmental orientation of the cultural, social, and economic dynamics drivers by the diffusion of the information technologies.”

A comparison of the two definitions identified the sociocultural and economic solutions associated with ecodesign and the technology solution. In other words, the first suggested the repair solution and the second suggested the rethink solution. The different approaches toward ecodesign from environmental experts suggested that the same differences in perspective may be observed among industrial designers (Figure 2).

Nowadays, even though the term “ecodesign” may be more frequently used by the general public, new terms, such as “Eco-Innovation” and “Design for Sustainability,” have emerged in the academic literature. Eco-Innovation approaches focus not only on the products themselves but also on the new services and new management and business methods. It also involves the creation of novel and competitively priced goods, process, systems, services, and procedures that can satisfy human needs and ensure a good quality of life for all people with a life-cycle-wide minimal use of natural resources (material including energy carriers and surface area) per unit output and a minimal release of toxic substances [23]. Design for Sustainability focuses on the challenge of transitioning towards a sustainable society, by integrating social, economic, environmental,
and institutional aspects and by offering opportunities to get involved and express one's own identity beyond consuming standardized mass products [24]. These new terms improve upon what was described during the early studies on ecodesign, with the goal being more sustainable production and consumption.

7. Survey Results

7.1. Personal Attitudes of Industrial Designers toward Environmental Issues

Many authors [25, 26] recognize the importance of industrial designers in ecodesign activities; their participation in the various stages of product development is invaluable. Consequently, there is also a need to understand how industrial designers can promote sustainability, which is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. According to Bakker [14] and Bhama [25], industrial designers have a valuable role to play in ecodesign because of their positioning at the early stages of the product development process, where design specifications may be modified on the basis of cost, appearance, material selection, innovation, performance, environmental impact, and quality (Figure 3).

Toward the considerations above, in this section, the author discusses the industrial designers' positions, personal attitudes toward environmental problems, and different ways of approaching sustainable product development. Practical exercises have been adopted by many companies based on the Ecodesign Awareness Workshop put forward in the Ecodesign Manual by Brezet [12]. Subsequently, industrial designers were asked to identify their positions on environmental problems regarding four factors: technology, socio-cultural (behavior), economics, and ecology.

As seen in Table 3, industrial designers compared the four factors and ranked them from 1 to 4, with “1st” representing the most important factor and 4th the least important. Respondents did not necessarily work on environmental product issues at their respective places of business. Their answers revealed that the socio-cultural factor (fundamental changes in individual attitude and changes in consumer lifestyles) was viewed as particularly important in solving current environmental problems (14.2%).

The second most important factor was economics (12.5%), which took the top position in order rank. Developing and applying environmentally friendly technology earned a response of 11.2%, and nature conservation, 14.9%.

Judging by the survey results, it can be noted that the industrial designers paid more attention to socio-cultural principles (behavior) than technology and economic principles.

At the personal (not corporate) level, they showed a proactive position toward finding eco-friendly solutions to current environmental problems. In other words, they responded based on an internal stimulus, such as ethics or a sense of responsibility. Respondents prioritized human behavior over technology in developing an approach to sustainable development (Table 4).

7.2. Attitudes of Operational and Strategic Designers Toward Environmental Product Development

Operational and strategic designers conveyed contradictory attitudes regarding environmental awareness and product development. Corporate designers gave more importance to the traditional performance–quality of product and sytling/visual aesthetic appeal. They did not regard environmental friendliness as a crucial factor for product competition and development (Table 5). Interestingly, the same considerations were given by industrial designers whose jobs required their involvement in environmental product concerns. At the personal level, they gave more attention to environmental concerns and considered them to be an integral part of product development. They became proactive when trying to convince a client or company to give heed to environmental issues (Table 4).

7.3. Involvement of Industrial Designers in Environmental Product Development

According to the responses from industrial designers of small/medium and large companies, most large companies (77.9%) have a special employee group or department responsible for environmental policy, while the small/medium companies are less inclined to have this structure (31.7%) (Table 6).

Industrial designers employed in design departments of large companies, therefore, were less likely to be involved in activities directly related to environmental policy (25.1%).
The majority did not have experience with ecodesign and felt the need to become more involved with relevant activities. This finding indicates that most large companies do not have an effective system to integrate designers in environmental activities.

Further, an analysis of industrial designers involved with either active or passive products revealed that 68.3% involved with active products were employed by companies with an employee group or department assigned to environmental policy issues. However, industrial designers involved in passive product development participated more actively in environmental policy than those who worked on active products (37.8%) (Table 7).

7.4. Industrial Designers and Their Knowledge of Ecodesign Principles

As Mackenzie [26] noted, designers play a key role in linking the manufacturing process and the consumer, as well as technology and marketing; they are the central figures in product development for many companies. However, this position must now be justified. Industrial designers must demonstrate an ability to solve complex and challenging issues associated with designing for minimal environmental impact.

Other experts [12-14] involved in environmental product concerns suggest that designers need both knowledge and understanding of environmental problems, the ability to seek guidance, and a technical understanding of the production process and the properties of materials.

The goal of this section, therefore, is to assess industrial designers' knowledge of ecodesign principles on the basis of a standard question formulated by the author and already adopted by many companies throughout the world (Table 8).

7.4.1. Life Cycle Assessment (LCA)

From the responses to survey question (1), the author discovered that 27.2% of industrial designers involved in environmental product concerns had used LCA during the product development stage. However, 72.8% had not used or were not familiar with it.

According to many ecodesign experts, LCA is essential for the environmental improvement of products. It is a model that describes all processes necessary for the extraction, cultivation, and processing of raw materials, as
well as the manufacturing, distribution, consumption, and disposal of the product. Survey responses indicated that industrial designers have not received adequate training regarding LCA for the purpose of product development.

7.4.2. The International Organization for Standardization (ISO 14001)

From survey question (2) regarding ISO 14001, it was noted that 22.1% of industrial designers involved in environmental product concerns had used this standard during the product development stage. A large percentage (77.9%), however, had not used it, or admitted that they did not know of it. Major Japanese companies, though, have implemented ISO 14001. For example, the law requiring recycling of specific kinds of consumer electrical goods was approved in 1998 and put into practice in April 2001; it was designed to encourage manufacturers to take back and recycle the four main categories of home appliances (television sets, air-conditioners, refrigerators, and washing machines). While it can be assumed that ISO 14001 and training in environmental laws have not been introduced formally to designers for their practical work, a new law promises to require more of their attention to environment concerns in the near future (Akermark) [13].

7.5. Environmental Information for Industrial Designers

7.5.1. Use of Environmental Information by Operational and Strategic Designers

Both operational and strategic designers involved in activities associated with environmental product development considered ecodesign as the most important topic for their profession. In other words, they gave more attention to information about recycling and disassembly when formulating product designs. The second most important information topic for operational designers was basic information on product life cycle (i.e., data on eco-toxic substances); strategic designers required external information (e.g., trends in green marketing consumerism). Both types of designers confirmed their involvement in environmental activities at the product development stage, but operational or instrumental designers paid more attention to the physical principles and technical details, while strategic designers focused on business decisions and commercial performance of products (Table 9).

According to Bakker's research [14], 173 Dutch industrial designers were surveyed about their use of environmental information. Table 10 shows that Japanese designers paid more attention to physical principles and the technical issues (recycling and disassembly), while the Dutch designers gave their attention to strategic decisions (determining which alternative was most benign). As shown in Table 11, both operational and strategic Japanese designers with or without experience in environmental product concerns relied on design magazines, periodicals, newspapers, fairs, colleagues, and in-company experts for answers to their inquiries about environmental issues.

7.5.2. Environmental Information Used by Industrial Designers Involved with Active and Passive Products

Table 12 shows that industrial designers involved with active products and with passive products agree that there is far too little environmental information available for their profession, 50.5% and 41.5% , respectively. They are interested in acquiring job-related knowledge about ecodesign methods and current trends in recycling design, disassembly, and green marketing consumerism (external information) (Table 13).

Energy conscious design is a topic that appeals more to designers of active products. The different approaches to environmental concerns and product development can be summarized as follows: industrial designers working with active products were more conscious of energy use and environmental impact of the product during the use phase (energy consumption and the amount of emission), while industrial designers working with passive products gave their attention to eco-toxic substances, green marketing consumerism, and examples of environmentally friendly products.

Other differences in the approach to information were noted for eco-products and related materials. Industrial designers of passive products gave more importance to this topic than those working with active products. Differences in perception can be attributed to the nature of the products themselves; active products are characterized by complex life cycles and environmental effects, while passive products are less complex. Therefore, active products are generally not conducive to reuse, while passive products may be reused or recycled.

7.6. Discussion of Survey Results

The author found that industrial designers were personally proactive about environmental issues; as professionals working in the design departments of companies, however, they tended to be reactive. Personally, they considered human behavior to be the most important factor for solving environmental problems; professionally, they indicated that they would rely on technology for solutions.

Industrial designers assigned to ecodesign activities responded with technological solutions or repair solutions toward environmental issues. The author, therefore, describes eco-redesign thinking as the focus by industrial designers during the design and product development phase on recycling and disposal of products. This attention to physical concerns may be related to the present high cost of introducing ecodesign principles into product development and to the prevalence of technical problems, such as recycling limitations for specific materials.

<table>
<thead>
<tr>
<th>Table 8. Industrial Designers and Their Knowledge of Ecodesign Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>(sample size n=197)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>1 During the development stage did you use the LCA?</td>
</tr>
<tr>
<td>2 During the development stage did you use the ISO 14001?</td>
</tr>
</tbody>
</table>
Table 9. Environmental Information by Operational and Strategic Designers
(sample size: Operational $n=87$, Strategic $n=110$)

<table>
<thead>
<tr>
<th>Environmental Information</th>
<th>Operational (%)</th>
<th>Strategic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design for recycling and disassembly</td>
<td>19.2</td>
<td>20.1</td>
</tr>
<tr>
<td>2 Data on eco-toxic substances</td>
<td>14.8</td>
<td>12.9</td>
</tr>
<tr>
<td>3 Environmental costs</td>
<td>14.1</td>
<td>10.8</td>
</tr>
<tr>
<td>4 Environmental legislation</td>
<td>11.5</td>
<td>7.2</td>
</tr>
<tr>
<td>5 Examples of environmentally friendly products</td>
<td>10.5</td>
<td>11.2</td>
</tr>
<tr>
<td>6 Energy conscious design of products</td>
<td>10.2</td>
<td>9.6</td>
</tr>
<tr>
<td>7 Trends in green marketing consumerism</td>
<td>8.9</td>
<td>12.4</td>
</tr>
<tr>
<td>8 Environmental assessment methods</td>
<td>8.0</td>
<td>13.8</td>
</tr>
<tr>
<td>9 Other</td>
<td>2.8</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Table 10. Environmental Information by Japanese and Dutch Designers
(sample size: Japanese $n=197$, Dutch $n=173$)

<table>
<thead>
<tr>
<th>Environmental Information</th>
<th>Japanese Designers (%)</th>
<th>Dutch Designers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design for recycling and disassembly</td>
<td>20.1</td>
<td>13.8</td>
</tr>
<tr>
<td>2 Data on eco-toxic substances</td>
<td>15.0</td>
<td>19.2</td>
</tr>
<tr>
<td>3 Environmental costs</td>
<td>13.2</td>
<td>6.9</td>
</tr>
<tr>
<td>4 Energy conscious design of products</td>
<td>12.0</td>
<td>9.0</td>
</tr>
<tr>
<td>5 Trends in green marketing consumerism</td>
<td>11.0</td>
<td>6.8</td>
</tr>
<tr>
<td>6 Examples of environmentally friendly products</td>
<td>8.9</td>
<td>10.0</td>
</tr>
<tr>
<td>7 Environmental legislation</td>
<td>9.0</td>
<td>8.0</td>
</tr>
<tr>
<td>8 Environmental assessment methods</td>
<td>7.8</td>
<td>26.3</td>
</tr>
<tr>
<td>9 Other</td>
<td>3.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 11. Environmental Information Sources used by Japanese Designers
(sample size: Operational $n=87$, Strategic $n=110$)

<table>
<thead>
<tr>
<th>Information Sources</th>
<th>Operational (%)</th>
<th>Strategic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design magazines, periodicals, newspaper</td>
<td>25.9</td>
<td>28.1</td>
</tr>
<tr>
<td>2 Fairs</td>
<td>16.1</td>
<td>14.2</td>
</tr>
<tr>
<td>3 Colleagues and in-company experts</td>
<td>14.5</td>
<td>13.1</td>
</tr>
<tr>
<td>4 Suppliers and producers</td>
<td>13.5</td>
<td>14.9</td>
</tr>
<tr>
<td>5 Technical documentation (handbooks, catalogues, etc.)</td>
<td>7.6</td>
<td>7.8</td>
</tr>
<tr>
<td>6 Seminars, workshops and trainings</td>
<td>6.2</td>
<td>10.0</td>
</tr>
<tr>
<td>7 Other</td>
<td>6.0</td>
<td>1.1</td>
</tr>
<tr>
<td>8 Client</td>
<td>4.2</td>
<td>5.3</td>
</tr>
<tr>
<td>9 Databases and computer programs</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>10 Experts from outside the company (consultants)</td>
<td>1.3</td>
<td>3.2</td>
</tr>
<tr>
<td>11 Scientific Literature</td>
<td>1.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 12. Personal Consideration for Environmental Information Available for Industrial Designers Profession (sample size: Active $n=102$, Passive $n=95$)

<table>
<thead>
<tr>
<th>What do you think of the following statement: “There is far too little environmental information available for industrial designers profession”</th>
<th>Active %</th>
<th>Passive %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>50.5</td>
<td>41.5</td>
</tr>
<tr>
<td>Neutral</td>
<td>20.2</td>
<td>30.2</td>
</tr>
<tr>
<td>Disagree</td>
<td>29.3</td>
<td>28.3</td>
</tr>
</tbody>
</table>

Table 13. Environmental Information by Designers involved with Active and Passive Products (sample size: Active $n=102$, Passive $n=95$)

<table>
<thead>
<tr>
<th>Environmental Information</th>
<th>Active%</th>
<th>Passive%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design for recycling and disassembly</td>
<td>22.2</td>
<td>18.3</td>
</tr>
<tr>
<td>2 Trends in green marketing consumerism</td>
<td>14.6</td>
<td>15.1</td>
</tr>
<tr>
<td>3 Energy conscious design of products</td>
<td>14.3</td>
<td>7.4</td>
</tr>
<tr>
<td>4 Data on eco-toxic substances</td>
<td>13.5</td>
<td>14.9</td>
</tr>
<tr>
<td>5 Environmental legislation</td>
<td>11.4</td>
<td>10.3</td>
</tr>
<tr>
<td>6 Environmental costs</td>
<td>11.1</td>
<td>11.2</td>
</tr>
<tr>
<td>7 Environmental assessment methods</td>
<td>8.7</td>
<td>8.5</td>
</tr>
<tr>
<td>8 Examples of environmentally friendly products</td>
<td>4.2</td>
<td>14.3</td>
</tr>
<tr>
<td>9 Other</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
and quality control issues.

According to Burgh [27], the main motivation behind recycling initiatives in Japan to reduce the waste stream and final treatment is Japan’s landfill shortage, not environmental concerns.

Many environmental experts [22, 28] believe that eco-redesign thinking is not sufficient for attaining real solutions—an issue that is becoming increasingly obvious to all those who work closely on environmental problems. They add that environmental concerns must be given the same priority as other traditional design factors such as quality, performance, styling, and ergonomics. An environmental focus must be introduced at the initial stages of product development so that the product can be reviewed in its entirety in terms of concept, function, and service. Such a review will consequently influence production and consumption of the product.

8. Conclusion

The ecodesign-related activities of industrial designers in Japan were characterized as activities related to ecodesign competitions, with the main objective being to stimulate industrial designers to propose new solutions. From an academic perspective, some studies on industrial designers in relation to ecodesign were noted. Themes related to the role of industrial designers in ecodesign were trivial. In reviewing the definition of ecodesign from the nineties until the present day, it is found that approaches to ecodesign were initially based on life cycle assessment. Presently, ecodesign has a wider and more complex meaning, with sustainability being the main goal for experts, which includes the concept of sustainable production and consumption.

According to the survey results collected during the nineties, industrial designers were proactive about environmental issues at the personal level; they considered socio-cultural principles as more important than technology when seeking solutions to current environmental problems. However, as professionals working in corporate design departments, they tended to be reactive toward environmental concerns. In fact, they showed little knowledge of ecodesign principles during the product development stage. ISO 14001 had not been introduced then, which would have served as a resource for their work assignments, and consequently, their knowledge of environmental laws appeared to be minimal.

The industrial designers also seemed generally unfamiliar with the concept of life cycle assessment during the product development phase, which implies that designers also had little knowledge of the environmental impact that can be caused by their products in each phase of the product’s life cycle. External factors were the main impetus for the implementation of environmental safeguards in product development, indicating that industrial designers are generally reactive toward environmental concerns.

Most industrial designers working with active products were employed by companies that had a special employee group or department responsible for adherence to environmental policy. Interestingly, the participation of passive product designers in ecodesign was greater than of designers involved with active products. Operational designers paid more attention to the physical principles and technical details, while the strategic designers focused on business decisions and commercial product performance.

Industrial designers of active products were more energy conscious than those working with passive products; the latter group was more interested in producing environmentally friendly products.

9. Future Issues

This research work discusses industrial design during the late nineties, early activities of ecodesign in Japan, and ecodesign-related activities of industrial designers. Survey results indicated that the ecodesign-related activities of industrial designers employed at the companies were not significant. Ten years have passed since the survey was conducted in the period from 1999 until 2001, and new terms related to design and environmental issues have emerged, including “Eco-Innovation,” “Design for Sustainability,” “Eco-Service Development,” and “Sustainable Product Development.”

Unfortunately, steps for integrating the skills of industrial designers into the early stage of products and services development have not yet been clearly defined nor have the skills been formally integrated into the process. From an academic perspective, some Japanese institutions (universities and organizations) have recently introduced short ecodesign workshops and lecture courses. However, a long-term ecodesign education curriculum has not yet been formally established within industrial design programs.

From a resource perspective, many of the tools and much of the information currently available is insufficient for the needs of industrial designers in terms of content, language, presentation style, and means of access.

Educational and resource limitations contribute to the lack of appropriate skills among industrial designers to integrate ecodesign into the early stages of product and service development. A review of papers presented at the International Ecodesign Symposium from 1999 to 2011 (Japan) [3-9] indicates that there is a significant lack of research from the designer and design educator perspectives, as well as insufficient research that explores in detail the pedagogical methods and resources appropriate for educating industrial designers in ecodesign.

Finally, it is imperative that practical and academic programs for industrial designers, design educators, and students of design use better methods and tools for a more effective integration of their design skills in the development of products, services, and product-service systems. The present author will continue to research areas related to this issue, which could stimulate industrial designers and design educators to demonstrate their ability and creativity to solve complex and challenging issues related to the design of products and services with minimal environmental impact, and consequently lead to more sustainable production and consumption of the products.

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Reference


