Hittite Journal of Science and Engineering, 2015, 2 (1) 103-114
ISSN NUMBER: 2149-2123
DOI: 10.17350/HJSE19030000016

Improving Fundamental Values and Environmental Awareness in Sustainable Engineering Education through Laboratory and Design Experiments

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Article History:
Received: 2015/01/08
Accepted: 2015/06/17
Online: 2015/07/01

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ABSTRACT

It is of the essence of this paper to attach importance to enabling prospective engineers to learn about simple and plain techniques and technologies of the past, while learning about the most up-to-date ones. The ancient and primitive handicrafts have gained importance as the requisites of sustainability and this has made old techniques and technologies popular again in the last 10 to 15 years, providing a significant area of research for international sustainability researchers. The historical awareness in this paper entails presentation of several examples from as far back as the primitive methods of the most ancient times. Perhaps, these methods are not directly used, but the paper aims to reach a conclusion with experiments that support sustainability by using similar simple methods to obtain simple prototypes that work with manpower. In this context, the paper conducts a basic research about the main objectives of sustainable engineering education. In addition to a comprehensive literature review, it considers environmental protection which is the main theme of sustainability particularly by presenting some results of laboratory experiments assigned to senior students for production of new material from waste materials. The paper illustrates a case analysis, original with its practical research methodology, and deals with the concept of sustainability with a decided awareness for history, environment, and design.

Key Words:
Sustainable Engineering Education; Historical and Environmental Awareness; Laboratory and Design Practices.

INTRODUCTION

The consequences of the Industrial Revolution experienced in the spheres of science and technology have tipped the scales of the ecological balance. Resulting ecological catastrophes included rapid loss of soil structure, extinction of species, desertification, acid rains, radioactive pollution, etc. Countries allocated part of their budgets to cope with and solve these emerging environmental problems and oriented their educational and political policies towards solving these issues. [1,2]. Therefore, it is of utmost significance to provide ecological training and also to train environment-conscious individuals in both solving environmental problems and in the protection of the environment. At this point, universities have a big share of responsibility. Although the young generation is not the instigator of the environmental problems, they are the people who will be affected from these issues and so they should be provided with more information, consciousness and sensitivity towards these problems than any other section of the community [1]. In countries like Turkey, where young people dominate the population, implementing environment protection measures could be possible only with a young population that has a high level of environmental awareness [3]. Apart from being an individual and social requirement, environmental education is also a right and should be evaluated under environmental rights. For this reason, it is an imperative to provide a training in which individuals are reminded of their rights and responsibilities in order to effect changes in their behaviors and to create a healthy, balanced and secure environment [4].

Being a lifelong education process, environmental training should be considered as part of training of any type and at any level. It was shown that students' levels of awareness for and sensitivity about environmental issues are irrespective of the grades they are in and that although they have a preconception of environmental issues and protection of resources, their daily practices and behaviors mismatch their level of knowledge. Accordingly, it was stressed that the efficiency of educational training given in undergraduate programs at universities in orienting attitude and behaviors should be questioned. It was further stressed that national strategies and policies are required for environmental training in institutions of higher education [1-5].

On the other hand, educational institutions that train engineers for corporations should teach about environmental issues and include communicative information from different engineering fields in their program as well as prepare their students for environment-friendly and sustainable production practices of the companies. In this context, Petersen's paper titled "The Potential Role of Design in a Sustainable Engineering Profile" investigates the profiles of engineers to be trained for the future and defends that sustainable design should be instilled with an interdisciplinary approach so that contemporary creative engineers could be trained [6].

A similar scholarly voice is heard in the article by Ochsendorf, titled "Sustainable Engineering: The Future of Structural Design": Here what needs to be taught is the global environmental influences and the importance of steel as a material; on the other hand, what could be contemporary solutions and sustainable structural designs; furthermore, what challenges await us in the future; and especially in engineering training the following should be taught: development of critical thinking, questioning hypotheses, seeking multiple possible solutions, solving open-ended problems [7].

The paper by Desha et al., titled "The Importance of Sustainability in Engineering Education: A Toolkit of Information and Teaching Material" dwells on the perils of climatic changes in recent years and considers the roles of engineers in sustainable development [8]. The paper questions engineering training and suggests renovations in the programs. Among many suggestions for new classes and courses are "Emerging Technological Innovations", "The Concept of Biomimicry - An Historical Context", and "Green Chemistry and Engineering – Benign by Design", which identify with the industrial design in the scope of this paper. These three suggested classes is a proof of our accurate synthesis of three fields for a multidisciplinary training of engineering, namely design-industrial product design- any engineering field –for example, chemical engineering- and history.

Another model study that underpin our paper is by Murphy et. al., titled "Sustainability in Engineering Education and Research at U.S. Universities" [9]. This article considers in detail engineering training at U.S. universities, and inspects the connection of classes/courses with the industry. They also define green engineering principles and fields; initially they display the current situation and then they determine what is lacking. All the authors are members to the sustainability center and suggest that green engineering principles should be applied at U.S. universities.

The aim of the paper

In the light of the facts above, and especially in the context of suggestions by Desha et. al. [8], research carried out by synthesizing multidisciplinary knowledge bring about exceptionally valuable information. Besides, information from many disciplines trigger opposite views for research, resulting in new ideas. Therefore, the aim of this paper is to synthesize information from three different and seemingly distinct fields, which draw nearer to each other thanks to the concept of sustainability, and provide a model for green engineering research as indicated by Murphy et. al. [9].

Main objectives of sustainable engineering education

One, perhaps the most important, objective of engineering training and education is to contribute to the development of social structure. In this context, Hilda Taba's "Social Studies Education" project and the experimental education project she conducted in San Francisco State University in early 1960s are of vital importance. The project ended two years later as she passed away in 1967; so the final report of the project was dedicated to her. The experimental project, "Social Studies Education", consisted of three significant sections and greatly influenced following training and education research and practice [10]:

"—Key Terms

Project materials should include such key terms as cultural change, interdependency, power, collaboration, conflict, and causality. These selected key terms should be managed and synthesized according to their own specific facts.

—Organization Ideas:

The five criteria or special factors for the organization and combination of the information and ideas learned after a unit is covered are below:

1. Meaning: Does it show important relationships

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according to different viewpoints? How will the main issues be studied?
2. Explanatory power: Is the knowledge helpful in explaining and understanding the problems people face today? What are the socially and culturally important issues?
3. Convenience: Is the knowledge suitable for the students' needs, interests, and development?
4. Endurance: Is the knowledge of any permanent significance?
5. Balance: Does the knowledge promote our understanding of events, individuals, actions or phenomena?

In education, learning spirals are quite old and trustable schematic illustrations. In Hilda Taba's long-lasting experimental work and in her posthumously published work, conceptualized spirals were introduced in educational practices. Received Hilda Taba's attention and interest and presented by Juran in the context of quality development, the spirals were further developed by Bostingls' thought, adapted and integrated into education in the concept of "Total Quality in Education".

The continuous improvement in total quality in education is revised in each turn of the spiral by perceiving the attained state, conceptualizing it, thinking, acting, and reacting against negativities and providing sustainability by grading improvement. This is, in a sense, reproducing previously existing values with a contemporary understanding.

"Quality Model in Education" proposed by Bonstingl [11] was designated as "Continuous Learning and Development Model" instead of the old model taught and employed before.

Quality model in education offers the following features: unlimited and continuous improvement; diagnosis and evaluation through orientation; a spiral ascension through self-control; progress-focused as well as goal-focused; a lifelong journey with a desire for learning; an integrated system that is complete with learner-teacher-manager and other complementary people as well as physical environment; a lively and meaningful learning process in which learners are proud of the results and wish for its continuity; a teaching team that remove obstacles; continuous improvement suitable for the vision and mission of the university; an interdisciplinary focus on research and learning; an instruction and management focused on people and institutions and their locations rather than the restrictions of curriculum-resources-method-time; international equivalence of the same instruction and management; transformation of instruction/learning processes – testing by process portfolios; a training that enables students to ask better questions; instruction that could be transferred to or taken from real life situations. Students who got conscious training will cause positive and fruitful processes and results. All these characteristics and features offered by quality in education could also be considered in sustainable engineering education in the scope of "occupational and ethical responsibilities related to engineering practices".

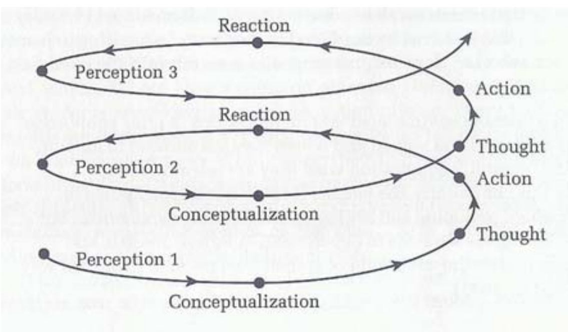

Figure 1. Bonstingl Spiral, [11].

"Rochester Institute of Technology" (RIT) could be counted among exemplary educational institutes in sustainable engineering education. Its educational programs have been designed in order to fulfill the following educational objectives and main goals:

- "Heightened awareness of issues in areas of sustainability (e.g., global warming, ozone layer depletion, deforestation, pollution, ethical issues, fair trade, gender equity, etc.).
- Clear understanding of the role and impacts of various aspects of engineering (design, technology, etc.) and engineering decisions on environmental, societal, and economic problems. Particular emphasis is placed on the potential trade-offs between environmental, social, and economic objectives.
- Strong ability to apply engineering and decision-making tools and methodologies to sustainability-related problems.
- Demonstrated capacity to distinguish professional and ethical responsibilities associated with the practice of engineering" [12].

Many more institutions could be provided as examples in terms of sustainable engineering education. All these institutions identify themselves with contemporary engineering education; it is certain that in terms of sustainability, they provide their students with environmental awareness. However, the examples that will be given in the scope of this paper will center on both the laboratory studies in engineering education and example projects that could be realized in Turkish design education as well as the differences they could bring about in sustainable engineering education.

Environmental awareness and environment-friendly production

When we look at the history of economy, we see that environmental issues have not emerged independently of people's life cycle but came into existence together with production and consumption and "...followed a course which was linked to the increase in production and consumption" [13].

After the inception of industrial revolution in England around 150-200 years ago, the mass production systems were copied by other countries. These developments encouraged people to consume more and the incalculably rapid growth of economy resulted in incredible pollution with chimney gases from coal operated factories, toxic waste from chemical industries, etc Although a delayed action, the number of enterprises that act sensitively in terms of environmental protection is growing bigger. Manufacturing enterprises should first learn about "environment-friendly production", which is an important standpoint of sustainable production.

"Environment-friendly production" is a concept that is synonymous with sustainable production. It could be defined as a manufacturing style which uses the least natural materials (e.g. forest products), which uses the least energy, which does not leave waste and which makes the product with the highest output. The main objective of environment-friendly production is stated as the optimizing resource materials without upsetting the balance of nature and minimizing the hazardous effects of waste on environment. To attain this main objective it is essential that the amount of waste and their flow should be defined, evaluated, and managed at the stages of product and process design, production planning, and production control.

Drawing on the work of Yücel and Ekmekçiler [14] explain that environment-friendly technologies fall under four main categories:

- "Technologies oriented towards eradicating the hazardous effects resulting from a procedure: These are the technologies that eliminate waste and other hazards resulting from production without making any changes in production process.

- Technologies that minimize raw materials, auxiliary materials, natural resource input and waste output by making changes in process. These are oriented towards changing the production process and production type. They are processes and final products that consume less energy, less water and less chemicals but work more efficiently and produce less hazardous waste.

- Recycling technologies: Technologies that enable reusing waste material by modifying them into new material, prevent littering, and minimize the consumption of natural resources.

- Old and traditional environment-friendly technologies: technologies that are inherently environment-friendly, in other words technologies that do not harm environment."

The technologies that seek solutions by changing processes are called "clean product-clean production" technologies. The main principle of clean production is to take preventive measures, not corrective ones. Accordingly, measures should be taken in order to use less raw materials and energy and minimize waste. For this end, ameliorating technological processes and developing new processes fall within the scope of sustainable production. The third item in the study by Yücel ve Ekmekçiler, recycling and reusing technologies have been in place for a long time. Waste paper, glass, metal, wood, and even plastics are recycled by breaking, melting, and are reproduced with various technologies as new materials of different types and purpose, and raw materials are used again [14].

Although few in number, old traditional environment-friendly technologies continue to exist especially in underdeveloped and developing countries. Small-sized enterprises that make production by handcrafts using semi-products still continue their handcrafting production today and earn their living with these production methods. Most of the medium-sized enterprises continue their half-machine-half-manpower production and operate in ateliers.

The literature shows that transition stage to sustainable production could be inspected in three groups: passive, active, and pro-active. Applied to product and services, clean production is a proactive production which is an integral approach and is listed in United Nations' environment program. In passive production, change meets with resistance and environmental requirement is considered costly. In active production, however, the environmental requirement is considered as activities that should be observed according to laws, regulations, and international protocols, etc. In proactive organization, environment is a priority subject of the enterprise and it is adopted and developed constantly by the employees.

Clean and sustainable production displays different characteristics according to the stage it is applied:

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1. Productions that avoid toxic and hazardous raw materials and economize on energy, time, and labor are sustainable.

2. Productions that exclude hazardous material, that design with the least raw material and have the highest output are indicators of a clean and sustainable production.

3. Services including supply chain and in more extensive chain of values which do not pollute the environment, which are economical and which provide customer satisfaction are clean and sustainable.

4. In the marketing of clean and sustainable production of food, "green marketing" invented by American Marketing Association in 1975 is an example of contemporary ecologic and sustainable marketing. Accordingly, the products have to carry environmentalist tags on them.

The notion of green marketing cannot be restricted to marketing process but it can be reflected in all production processes. For instance, although at experimental level the marketing of solar powered cars, or cars that use hydrogen gas -obtained by electrolysis of water- as fuel, include all production processes and stages.

In line with green marketing, there are labeling types including "eco-labeling", which symbolizes clean life cycle of the products; "disposable labels", which define one aspect of products, and "negative labeling" which is a compulsory labeling type that shows negative sides of the product in terms of its supplied form instead of its claims.

Manufacturing enterprises bear all responsibilities of a sustainable production. According to Ottman what lies in the foundation of this understanding is "...a reliable product for the welfare and happiness of the community, advertisements that reflect reality, protective activities for the environment, safety of personnel, and efforts to provide employment." The concept of reliable product leads to reliable production and brings to mind reliability of sustainability [15].

The notion of sustainability

Sustainability has emerged as a concept in 1970s together with the increase in raw material and energy sources and resulting upswing in environmental pollution. Global warming, rapid decreases in green areas of the world, rapid increase in human population, risk of draining all water resources, hunger, unemployment related to continual crises, social imbalances that could start crises in the world and similar reasons increase the importance of sustainability.

World Commission on Environment and Development (WCED) convened initially in 1984 and issued the Brundtland Report in the spring of 1987. The report defined "sustainable development" for the first time and expressed that humanity is able to persist in sustainable development [16].

At the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992, the strategies expressed in Brundtland Report were further improved by the representatives of 179 countries and it focused on the protection of natural resources, sustainability for all forest varieties, and climate change. The conference resolved that the main reason behind the ongoing deterioration of natural environment was that production and consumption were realized with unsustainable models especially in developed countries. Accordingly, strategic decisions were considered such as taking preventive strategic decisions, using energy and resources in more efficient production processes, researching about and preferring cleaner manufacturing methods in all processes of product life cycle, and minimizing waste both during manufacture and after consumption of the products.

With the 'White Paper' issued by European Commission in 1994, a political infrastructure was formed for sustainable production with the title "Growth, competitiveness, employment: new formations and methods on our way to 21st century". The significant information at the heart of this political infrastructure could be summarized as below: Raw materials should be used as efficiently as possible. Assembling techniques should be improved and recycling and reproduction capabilities should be supported. It is possible to recycle and reuse materials thanks to design measures to be taken during the planning of the product or the process. In the light of this information efficiency should be prioritized: efficiency should not be restricted to raw materials but it should cover all areas that have to do with time, money, and effort and should be reflected in the product functionality.

The 'design measures' mentioned in 'White Paper' emphasize the importance of sustainability of design. It is impossible to consider sustainability related to design on its own. Sustainability of design leads to considering the following:

- Sustainability of life and habitats,
- Sustainability of usage and consumption,
- Sustainability of production,

- Sustainability of design education. As areas of engineering are areas of design, their education is a part of the whole system.

Sustainable production is the prerequisite for sustainable design. The sustainable production principles established by LCSP (Lowell Center for Sustainable Production in USA) as their reason for establishment led to better acknowledgement and widespread practice of sustainability worldwide. Birdoğan, O'Brien, and Veleva et al. summarized in their respective studies the characteristic features of sustainable productions as below:

1. Environmental awareness should permeate the cultures of all organizations.
2. Sustainability should be given importance in all product and process designs of the enterprise.
3. Wastes and ecological impurities should be kept at a minimum during planning and implementation of production processes.
4. During product design, highest level of output should be considered, with minimum wastage of materials.
5. Modular design should be employed at a maximum in the entire manufacturing process.
6. Enterprises should be based on quality and efficiency, and goods and services should be manufactured with minimum input of resources.
7. They should improve the useful life of products by providing spare parts and means to reassemble [17-19].

There is a very comprehensive process and a chain of life cycle in the beginning and aftermath of a design project. In this context, it is initially compulsory to prepare safe surroundings and environment in terms of priority issues such as air, water, food, accommodation, etc. for sustainability of habitats and for preservation of future human habitat. In this issue, Birkeland's' definition of ecological scale unfold the designers' duties in a chained correlation which become more specialized from inside to outside:

- *"Bioregional Planning",* is an integral planning which include the holding capacity of regional, biologic life and ecologic systems, unique ecological features, shaping up lifestyles, production and management systems, etc.
- *"Urban Ecology",* second level from the outside, it represents the cities.
- *"Industrial Ecology",* mentions the economy of production processes and their environment protection efforts.
- *"Community Design",* points to the effects of development and settlements on ecologic balance.
- *"Construction Ecology",* describes economizing on materials in product structure and correct management of ecologic means.
- *"Eco-architecture",* ecologic designer should support designs that minimize operating effects of buildings with natural energies and develop human productivity.
- *"Ecodesign":* An eco-logical designer works in order to decrease the amount of toxic materials and energy amounts consumed up in the industry and households, ease demounting, and minimize waste caused by status-lover consumers through reusing and recycling [20].

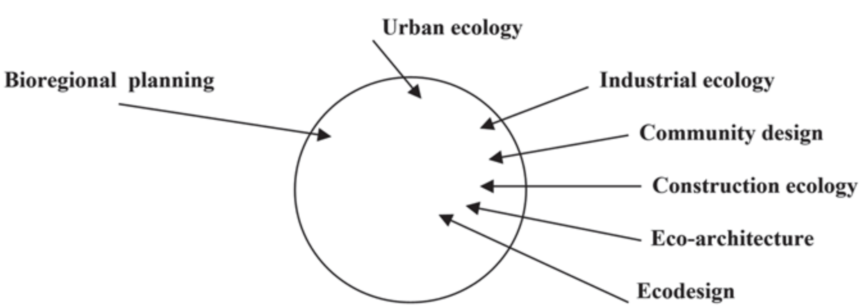

Figure 2. Ecological design areas exist in the whole of the scale [20].

Each of the areas in the ecologic design scale by Birkeland is related to all areas of life and practice. However, industrial ecology, construction ecology, and ecodesign are directly related to engineering fields.

Walker emphasizes that improvisations in design is possible by using the limited means at hand, and adds that there are few applicable a priori solutions and that a more sensitive type of design, and creativity should be encouraged. The source of such an approach is described as vernacular and local design because there is a perfect harmony among material values, beliefs, and ways of life of traditional cultures. The objects in these cultures have deep and symbolic meanings above and over their functional benefit:

> "We can learn from the craft and folk design traditions. However, we have to find ways to integrate the vernacular to the global in order to create designs that are suitable for modern communities developed in terms of technology and economy. This integration would be a progress for the industry in the closing of the profound gap between craft and design" [21].

Walker's proposal for the synthesis of the vernacular and the global, hints that the vernacular should be considered until the most ancient of fundamental values.

Comparison of sustainable design

It is not very easy to get used to the notion of sustainable design. For one thing, it is quite difficult to make design with sophisticated restrictions and without the definitions of designs we have learned, applied, and experienced until today. Nevertheless, now they will need designers' imagination, creativity, and innovation. The need for innovation have to be met by using the most advanced technologies, the least hazardous productions, the minimum amount of materials, catering for the local cultures and with awareness for social-environmental-economic responsibilities.

Table 1. Reshaping design: comparison of characteristic features [21]

Traditional Design	*Sustainable Design*
Industrial design	*Design of functional objects*
Product design	*Creation of material culture*
Specializing	*Improvisation*
Traditional	*Indefinite, indisposed*
Specific	*Integral, complementary*
Beneficial	*Unique*
Problem-solving	*Experimenting*
Solutions	*Possibilities*
A priori design	*Dependent design*

When comparing traditional design with sustainable design, Walker puts on the foreground the design of functional objects, which is already part of industrial product design. This leads us to the area of 'design engineering' and emphasizes the necessity that functional objects with minimum materials should directly interact with the users. It is suggested that sustainable design is dependent on environment, is integral and unique, it is experimenting while meeting spontaneous needs of people who became one with environment, and provides prospective life experience with future possibilities.

In line with this information, researchers of sustainability stress that future developments should be revised with the established values of the past, that communities put forward their material culture depending on their environment, and thus they underline the fact that historical beauties of the environment form the infrastructure of cultures in the scope of sustainable design.

Anatolian Mining and its reflections to our time in the context of fundamental values

Mining dates back to the most ancient times in Anatolia. It can be said that Anatolia is the homeland of mining. According to Sevin copper was molten at around 1200 °C in Değirmentepe on the banks of Euphrates at around

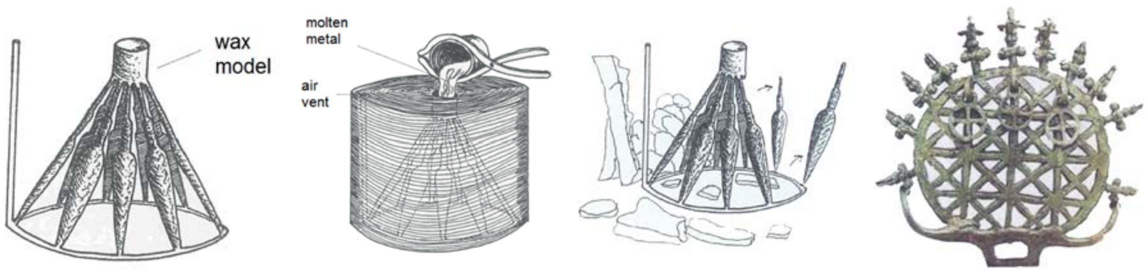

Figure 3. a) Second half of 3rd millennium B.C., vanishing wax method, wax model [22] b) Vanishing wax method, casting of molten metal, c) Vanishing wax method, cast product from bronze alloy cooled down, d) Old Bronze Era, Bronze "Sun Disk" found at Alacahöyük, 'BM' Mausoleum (2500 B.C.), It is thought to be produced with vanishing wax method. It is the symbol of Ankara University [23]. Used as the tip of ceremonial wand, the sun disk is thought to represent the "Sun God" [24].

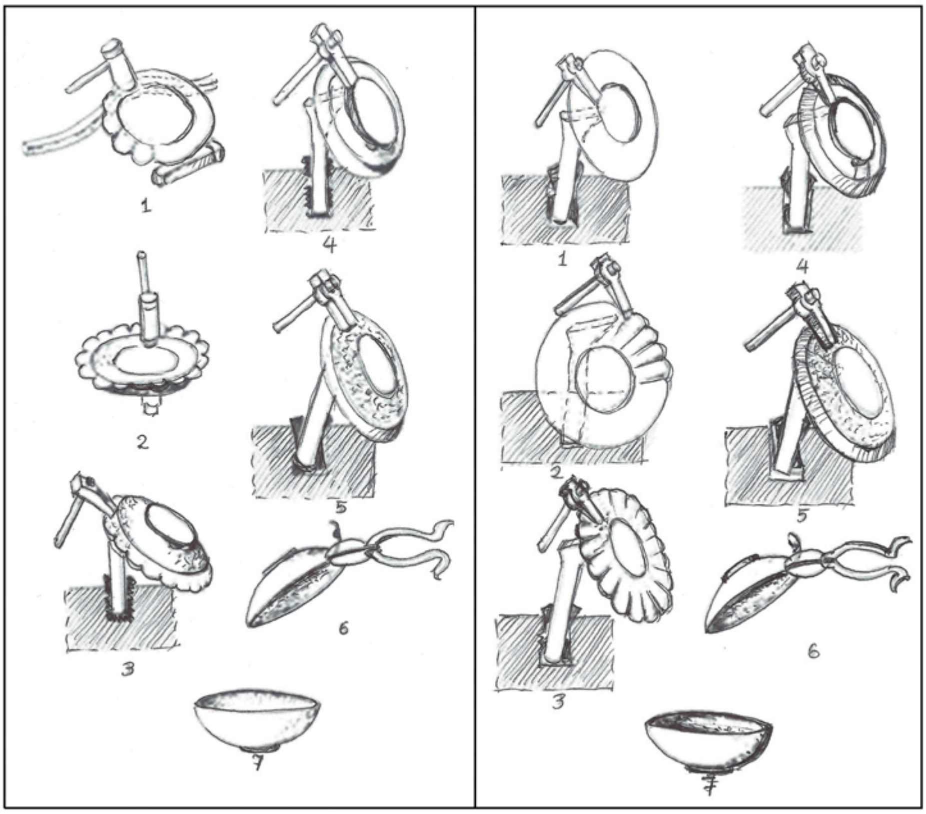

Figure 4. Metalworking techniques. The first group shows embossing partly with a free hand; the second group shows procedures with a supporting stand [26].

5th millennium B.C. Early Bronze Age saw the production of tools and arms at industrial levels, and local ateliers started to appear:

> "Dazzlingly artistic designs were made using sophisticated casting techniques by obtaining a bronze alloy by tossing either arsenic or tin into copper. In the second half of 3rd millennium B.C. a new technique emerged called "vanishing wax method" (cire perdue). In this method, initially a wax model was prepared and this was covered to make a mold. Heating the mold caused the wax to melt, and then liquid metal was poured in the mold. The mold was broken after it cooled down and the desired form was obtained. Sun disks at King's mausoleums in Alacahöyük were cast using this technique." [22]

Kuban also shows that techniques such as molding, embossing, soldering, and inlaying were developed around end of 3rd millennium B.C. Hattis, who lived in modern Kültepe region in Central Anatolia, are known to have kept up and mastered metal works starting with the initial period of 2000-1750 B.C. Coppersmith's tradition which evolved in thousands of years in Anatolia (Figure 4) still uses embossing method [25]. Traditional method is ready in the mind of the coppersmith. An object of daily use (Figure 5) was obtained

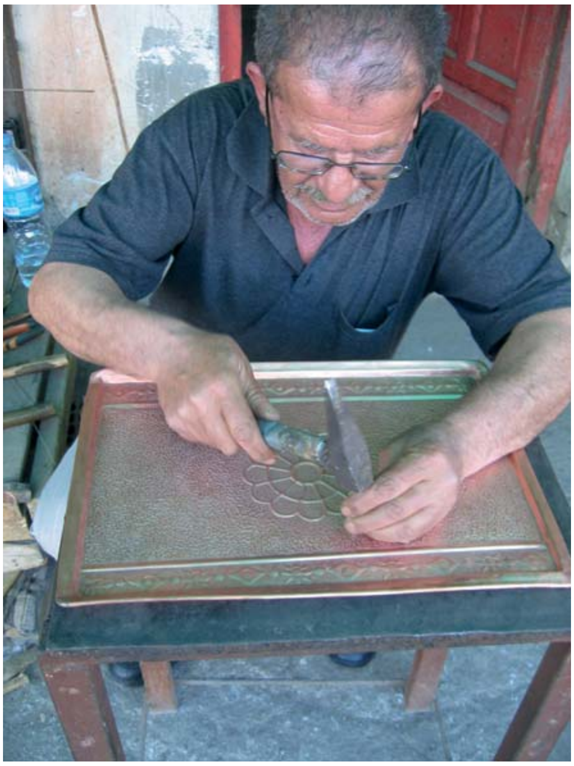

Figure 5. Forming the copper tray with embossing method; the tray is completely made with traditional method. Design S.Satir, Production: Zülfikar Usta.

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Figure 6. a) Tricycle to carry water demijohns, b) A manpowered vehicle to carry mail, c) Manpowered vehicle to sell flowers

after the method is transferred into an experimental and contemporary work with the collaboration of craftsman-designer.

What's more, 96.4% of Turkish economy is made up of SMEs and these enterprises usually own small ateliers where they make mostly crafting manufacture. With this viewpoint, and referring to 4th item of environment-friendly technologies in Yücel and Ekmekçiler [14], S. Satir covered the topic of handcrafted tools and vehicles made with semi-product materials in the lecture with undergraduate students at ITU-Industrial Product Design Department "Manpowered Vehicle Designs" seen in Figure 6 were realized. The materials suggested for these devsigns and their manufacture are ideal case analyses for the notion of sustainability.

The reason for the dense concentration of simple and plain products in culture-related fields is the solid structure of time-honored and ongoing traditions dating back to prehistoric periods. In this context, sustainability supports vernacular materials and production methods. If one most important aspect of sustainability is manufacturing with environment-friendly materials, other most significant facets include recycling vegetal waste with environmental concerns, and laboratory work in chemical industry, such as eliminating dyeing material from waste water in textile industry.

Laboratory work with environmental awareness

Engineers are important people in the development of their country: It is essential that besides what is contemporary, they have to observe the sustainability of natural and economic resources for healthy, secure and prosperous generations. Accordingly, it is an established fact that engineers have to be trained in environment and ethics besides a good quality technical training. Nevertheless, not enough environment and ethics classes could be incorporated in a formal education of four years.

With 2000s on, besides engineering standards, ABET added into its accreditation criteria for engineering faculties the requirement for students to prove their knowledge in economy, environment, sustainability, manufacturability, ethics, reliability, and social and political issues. It is emphasized that students should be helped to develop skills to analyze events and phenomena from historical and social viewpoints and generate ideas, and that approaches and practices that might limit their horizons in the narrow confines of the trade should be avoided.

Besides the classes related to environment, students could be assigned projects in order to provide them with environmental awareness. For instance, people have been eradicating forests to manufacture wood-based furniture,

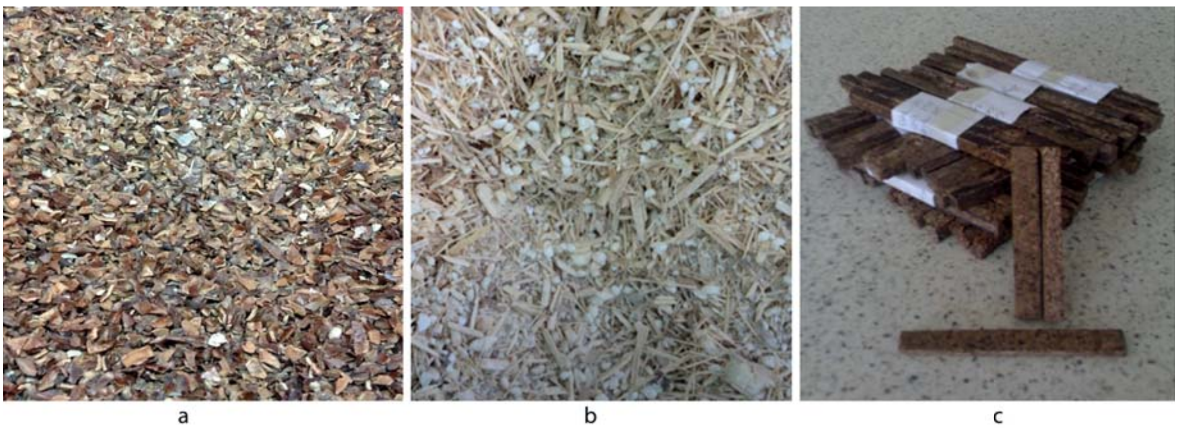

Figure 7. a) Waste walnut shells, b) Sunflower stalks, c) Composite material produced in the laboratory.

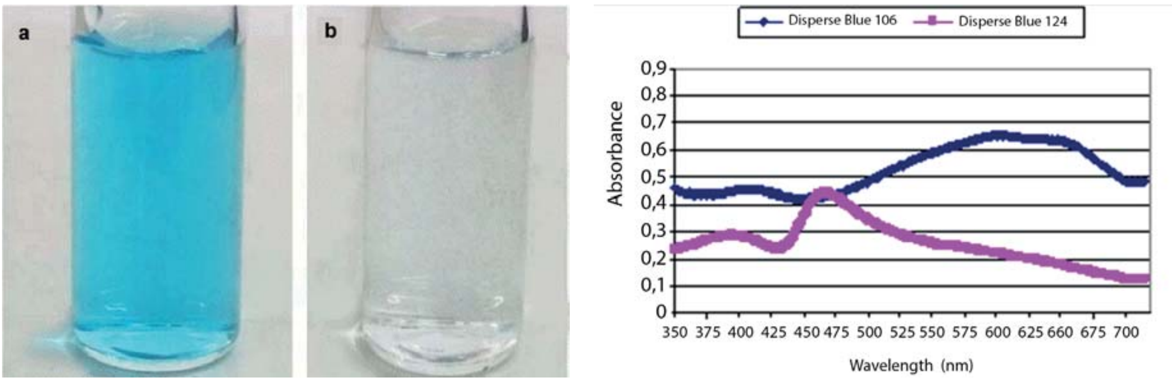

Figure 8. a) Before adsorption, b) After adsorption, c) The A-λ graph for disperse blue 106 and 124 [27]

construction and decoration materials. Although with the advancement of technology wood has been replaced in many sectors by materials such as plastic, metal, aluminum, concrete, and cement products, it is still preferred in the construction sector because of the warmth it adds to living environment. However, the decline in forests because of this reason and the difficulties in growing new ones in a timely manner to replace these trees make alternatives for wood more and more valuable. In this context, in order to minimize the risks to forests and to provide the wood texture and to evaluate waste material such as walnut shells, hazelnut shells, rice husks, sunflower stalks, and bagasse, students were assigned to prepare new composite material that is alternative to wood. Relative cheapness and availability of these filling materials for composites of this type make it cost- effective and make it possible to recycle waste material.

In the experiments, initially, walnut shells, hazelnut shells and sunflower stalks were obtained domestically, and ground to the required size. Waste materials (Figure 7a-b) were mixed with auxiliary material at varied rates according to prescribed recipes. Different homogenous mixtures were added phenol formaldehyde resin as binding agent. Hot press was applied to homogenous materials at 110°C at a pressure of 100 bars for 15 minutes. For pressing procedure predetermined optimum values for temperature, pressure, and time were used. Following the procedure the composite materials were cut with a compass saw to required size for analysis (Figure 7c). Pressed and resized samples were given standard tests for physical and mechanical strengths and checked for their suitability to use in various industrial sectors.

Another project assigned to engineering students besides theoretical classes in order to provide them with environmental awareness was adsorbing certain textile dyes and heavy metals from water using cheap waste material as adsorbents. The aim of this experiment was to provide students with environmental awareness by reusing waste material and concretize how worthless material could be commercially evaluated.

In this experiment, use of naturally available and cheap adsorbents such as walnut shells and hazelnut shells was tested in the disposal from waters of disperse blue 106 and disperse blue 124 pigments which are widely used in particularly textile industry to increase visual attractiveness. The effects of pH value, grain size and grain amount on the adsorption process in waters with different pigment concentrations were inspected. In the light of the findings (Figure 8) from experiments under different working conditions, it was seen that used waste material were effective in the disposal of pigments from waters.

In the disposal of disperse blue 106, 358 walnut shells were employed with an average grain size of 855 μm, while 855 hazelnut shells were employed with an average grain size of 1500 μm to dispose of disperse blue 124. The monoazo pigments of disperse blue 106 and 124 which were employed in the experiments were obtained from Sigma-Aldrich (Germany). The walnut and hazelnut shells used as adsorbents were domestically obtained and were subjected to resizing into grains and sieving before experiment.

CONCLUSIONS

This paper considers different fields of engineering with a holistic approach in the scope of sustainability with awareness for environment and fundamental time-honored values. Each engineering field has a rooted fundamental past. If this deep rooted past is evaluated with the history of the training country and its environment and the student is provided with awareness in this issue, the educational, historic, environmental, and social duties will be done. In the essence of this paper:

1. Hilda Taba's research [10] is dominated by concepts such as cultural change, interdependence, cooperation, contradiction and causality. Organizing the capacities of these key concepts and synthesizing information therein is of significant

importance. Hilda Taba's research symbolizes the fundamental past of engineering.

2. In Bonstingl's research [11], "Quality Model in Education" exhibits continuous learning and development. This spiral model allows for continuous auto-control and make it possible to evaluate ones past in a multidimensional way.

3. RIT's exemplary status in sustainable engineering education and its objectives cover almost all dimensions of environmental, social, economic, ethical, design concepts [12].

4. Yücel and Ekmekçiler [14] evaluated "old and traditional, environment-friendly technologies" in the scope of the subject matter.

5. Research by Birdoğan [17], Birkeland [20], Walker [21] supports the aim of this paper.

The supportive information in the literature review emphasize the significance of history and maintaining traditional fundamental values in the building up of environmental awareness. Similarly, the information that supports case studies was carefully selected. In this context:

Using local waste to preserve forests, or the experiment of treating pigmented water with hazelnut shells and sunflower stalks –a kind of waste-, to prevent contamination of water and land is very important dimension of the sustainability of engineering education.

Designing with semi-products and half machine half man power in small ateliers for future manufacture is again an utterly important design education experience. In this age of very sophisticated production technologies, it should not be very easy to support a semi-primitive production. However, in highly populated countries where the industry is mostly made up of SMEs, and high tech is scarce, supporting productions made with half-manpower will save energy.

At international level, RIT has a definite and ethical attitude in implementing sustainable engineering education. In Turkey, however, although environmental education is included in the curriculum as early as 1991, it still has the electives status. Therefore, for our country, it is not possible to talk about a standard training infrastructure or implementation at tertiary level in environmental issues at national level. It is essential that this training should not remain in theory but put into practice at an implementation phase which is adequate and is harmonious with course contents.

This is because institutions of higher education are responsible for training individuals who have knowledge, skills, and values necessary to contribute to the life quality of the global community.

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