Pre-service science teachers' views of the ecological footprint: The starting-points of sustainable living

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Received 21 Nov., 2009
Revised 19 Jun., 2010

Contents

Abstract

In this study, pre-service science teachers' opinions about the concept of the ecological footprint were investigated before and after activities about sustainable life and their ecological footprints were calculated. A total of 49 pre-service science teachers (31 male, 18 female) who attend third class in the science education department participated in this study. In the research, qualitative and quantitative research methods were used. After the sustainable life education, it was observed

that the pre-service science teachers' awareness of ecological footprint raised and their visions for the future developed.

Keywords: ecological footprint, sustainable living, pre-service science teachers, Turkey

Introduction

Education for Sustainability was proposed in 1997 in the Thessaloniki Declaration (UNESCO, 1997a) as a single message of hope for the future (Knapp, 1997). The message of Thessaloniki was that education, first and foremost, should be in the center of the international, regional and national agendas (UNESCO, 1997b). To make sustainability a reality, Mathis Wackernagel & William Rees developed an Ecological Footprint Analysis (EFA) as a measurement tool to determine whether humanity's demands remain within the capabilities of the globe's natural capital (Wackernagel et al., 1999). With documented declines in the biophysical state of the planet, the ecological footprint analysis has been promoted as a policy guide and planning tool for sustainability (Wackernagel et al., 1997).

The ecological footprint is an indicator of sustainability that converts consumption and waste production into units of equivalent land area (Flint, 2001). The ecological footprint is a model and teaching tool for measuring the ecological impact of nations and individuals (Wackernagel & Rees, 1996). Ecological footprinting is a stimulating way to introduce students to some of the less obvious but crucial dimensions of human ecology and to familiarize them with some of the ecological implications of a consumer society.

Over the last 30 years, the discussion on critical dimensions of sustainability in higher education has continued through the signing of multiple international declarations, the implementation of national programs and specific initiatives within universities (Clugston & Calder, 1999; Wright, 2002). However, they have mainly focused on developing curriculum, teaching and training students on the principles of sustainability. While there is no consensus on how best to actually teach sustainability at the university level, one approach, called problem-based learning, has recently received attention (Jucker, 2002; Steinemann, 2003; Warburton, 2003). The ecological footprint concept provides a simple framework for understanding the ecological bottom-line of sustainability. Putting sustainability

in simple and concrete terms helps to build common understanding and set a framework for action (Wackernagel, 1994).

When the related literature is reviewed, there are many studies showing that the ecological footprint is an effective tool in promoting sustainable-life related knowledge, attitudes and behaviours (Meyer, 2004; Ryu & Brody, 2006; Wada, Izumi & Mashiba, 2007), detecting non-sustainable life styles of schools and individuals (Dawe, Vetter & Martin, 2004; Janis, 2007) and raising students' awareness of the global and regional effects of their consumption patterns. However, there are few studies dealing with the importance of education and the measurement of the ecological footprint for national sustainable life (Keles, 2007; Akilli, Kemahli, Okudan, & Polat, 2008; Erdogan & Tuncer, 2009).

The present study is based on the belief that higher education has an important role to play in promoting the development of knowledge, skills and values, and the first group of people who should be informed about the concepts relating to sustainable development should be the student teachers that will assume great responsibility to shape the vision for the future. Hence, there is a need to determine their knowledge level of the issue. In this study, the goal is to produce well-informed science education pre-service teachers who can critically think about sustainable living and the ecological footprint and can therefore contribute to development of sustainability principles in their school and society. In this study, ecological footprints of pre-service science teachers, who will educate future generations, were calculated in order for them to see their effects on the world. The consumption category that mostly affects the ecological footprint was determined. Views of the pre-service teachers about the ecological footprint were researched. This study is important since teachers play pivotal roles in educating young people; hence, taking their views about sustainable development and training them is important to forward these studies to the future generations.

Methodology

Sample and Instrument

A total of 49 pre-service teachers (31 male, 18 female), who attend the third class in the science education department at Gazi University, participated in this study. In this study, the per-capita ecological footprint is measured by sixteen questions using the "ecological footprint quiz" that was created by Earth Day Network (2002).

The survey consists of 16 questions. Consumption activities for each survey question were weighted by a "footprint factor" calculated by the amount of energy and land needed to support the given activity. Footprint factors were pre-calculated by Redefining Progress according to national levels of productivity. Multiplying each respondent's level of activity by its corresponding footprint factor yielded an equivalent impact in terms of acres of land/sea that can be compared across all nations (Merkel, 2003). A composite ecological footprint score was calculated by aggregating four separate components: food, mobility, housing, and goods and services. The food component summed up land and marine areas that sequester CO_2 from the energy expended to grow, process and transport food. Survey questions included the types of food respondents regularly eat and where this food is produced. The mobility component was based on the impact from walking, cycling, driving cars and flying. Respondents were asked to provide information on their mobility habits including the mode, distance and relative energy efficiency of their daily travel or commute. The housing footprint component was based on yard area, energy and materials for constructing buildings. Specific questions included the size and type of shelter and the number of inhabitants. Finally, the goods and services component considered consumer behavior patterns such as use of appliances, electronics, computers and communications equipment. Specific questions also obtain information about utility use including water, and trash disposal services.

There are numerous Internet sites in which web-based ecological footprint calculation can be done. A calculation instrument prepared by the Earth Day Network is a reliable scale since it is suitable to calculate individuals on global scale and in its development process. The ecological footprint approach is simple. It points out how much nature we need for a sustainable life. Its conceptual reliability has been measured with a convenient sensibility. Wackernagel (1994), Meyer (2004) and Ryu (2005) used this web-based calculation instrument in their research. The validity of the ecological footprint is provided by its conceptual reliability.

In the study, before and after the sustainable life education, pre-service science teachers were asked questions such as, "What is the Ecological Footprint? Define it with your own expressions" in order to learn their views about sustainable life.

Activities Performed in the Study

The activities of the study were preformed in a five-week period (three hours per-week). In the first week of the study, students were provided with graphics showing why the life on earth is not sustainable, and they were asked to discuss the reasons for this non-sustainability. In the second week, closed envelopes including the key concepts concerning why life in our country and on the earth is not sustainable were prepared. These envelopes were distributed to the students divided into groups, and then they were asked, "Why is the life not sustainable?" Afterwards, the students were asked to write the factors affecting sustainable development in order of precedence on a piece of paper by using the concepts given in the envelopes, and then they discussed their order with other groups. Students played monopoly (Sustainable Development Variable). In this game, the aim was to make the students realize the general wisdom in our global system; commerce, cooperation and competition improve production, money has an important role as a way of barter in this process, resources are unevenly distributed and that organization and entrepreneurship skills can affect the success of the individual. The researcher informed the participants about sustainable development, the principles of sustainable development and sustainable life. Following this informing activity, the pre-service teachers were divided into groups. They were asked to think of a cherry tree and then discuss how this tree sustains its life with their group members and then draw the process of the tree's sustaining its life on a piece of poster paper. The posters prepared by the groups were presented to the other groups. As a result of this activity, the participants realized that the only way of being sustainable is to learn it from the natural ecosystems. Then, the researcher drew pictures of a tree, money and a human being on the board, and the participants were asked to draw cartoons showing the connection among these items and think of a slogan for their cartoon. Based on their cartoons, the participants were asked to think once more about how the cherry tree sustains its life and realize the connections among the economy and environmental and social aspects that are vital in making the life sustainable.

In the last lesson of the second week, the participants were again divided into groups. They were given some poster paper and asked to draw the shapes of their feet on it and then were to roughly estimate the area of their feet cover in square meters. Then they were asked some questions such as, "Does every step you take have effects on the earth? May your lifestyle affect your footprint?, and based on

their responses to these questions, they wrote the components that they believe constitute their footprint around the shape of their foot. In this way, the background knowledge of the participants about what an ecological footprint is and what its components (water, food, energy etc.) are was tested. They were asked to discuss each component they wrote with their group members. Following this discussion, the ecological footprint calculation quiz was distributed to the participants, and their footprints were calculated on a computer.

In the third week of the study, the researcher informed the participants about the ecological footprint. Then, they were asked to think about the things they could do to minimize the effects of their footprints on food, energy, transportation, water, waste and society; they then wrote these items down. Then the participants were informed about the things that they can do to minimize the effects of their footprints by the researcher. Afterwards, the participants watched animations about energy, transportation, water, recycling, technological pollution, biodiversity and balance, traffic, hunting and the impacts of human activities on nature. After they watched each animation, they were asked to write the message that fit the animation in just one sentence. Then, the students watched series of "Troubled Waters" and "The Difference of Half Degree" in "Odd Days of Our World 1-2" VCD and they were asked to think about the environmental problems our world faces and the footprints they leave on the earth.

In the fifth week of the study, participants were provided with many problem situations where they need to think about how to reduce the ecological footprint. Using the six-hat thinking technique, the students were led to the discussion of these problem situations. After the evaluation of the five-week education program with the participants, the education ended.

Analysis

Analysis of the quantitative data

In this research, quantitative data analyses were made using the Statistical Package for the Social Sciences (SPSS) Analysis Programme. In the research, the measure of central tendency values and central distribution values of food, habitation, transportation, and goods/services points of pre-service science teachers were reported and relations between points were examined using the correlation method.

Analysis of the qualitative data

The written responses explaining what is meant by the term ecological footprint were analysed in one way. The development of categories to capture the features of an ecological footprint appearing in the responses of the sample and counting their frequency of occurrence.

Categories capturing the features of ecological footprint

Each response was read and the elements within it were added to a summary sheet to build up a list of all the elements in all the responses. Categories for coding the elements were then generated from this list. It was found that the six categories shown in Figure 1 could be used to code all of the data. These categories can be thought of as the various features present in the students' explanations of the nature of ecological footprint. The analytical process then involved examining each response and using the categories to code the elements present. Note that once a given category had made an appearance in a response, further occurrences of the same category in the response were not coded. In other words, the responses were coded for the categories present-each category could only occur once (even though its presence may have been supported by several elements). Since one response usually contained several categories, the number coded was far greater than the sample size. This method of analysis was not used initially to make judgements about individual responses. Rather, it was employed to portray the frequencies of occurrence of the various features of sustainable development (the categories) in the sample before and after training.

The coding process

In this study, the categories used were developed by the author. The validity of the data analysis therefore relies on the credence given to the judgements made by the experienced science education teacher and the doctoral student who had considerable experience in researching science and environmental education. We provide examples of responses and their categorizations (Figure 1 shows) at various points in the paper to enable readers to appraise our decisions.

Figure 1. ***The Six Categories Used toCode Elements in the Responses***
1. Biologically productive land and water areas required to produce all the resources an individual consumes and to absorb the waste they generate
2. Intuitional measurement of the effect of individual/society on nature
3. Indicator of sustainability
4. The total effect of humans on the world
5. Environment policy and the calculation instrument used for environmental management
6. Others

Results

Before sustainable life education

Prior to the study, pre-service science teachers were asked to answer this question: "What is an ecological footprint?" The aim was to determine whether they had some prior knowledge about the concept. All of the pre-service science teachers replied to this question "I have no idea" in the pre-test. In the view of such data, it is seen that until the third year of university pre-service science teachers, who participated in the research, had no idea about the ecological footprint, which has an important place in sustainable life.

Results associated with distribution of the ecological footprints of pre-service science teachers

Table I shows the central tendency and distribution statistics of the values, which were obtained from the answers of pre-service science teachers who participated in the ecological footprint quiz and subsequent research.

Table I. *Ecological Footprint Statistical Analysis Results (n=49)*

	Ecological Footprint	**Food**	**Housing**	**Transportation**	**Goods/Services**
Mean	3.91	1.70	1.01	0.17	1.03
Median	3.90	1.70	1.00	0.10	0.90
Std. Deviation	1.26	0.36	0.56	0.21	0.58

As it seen in Table I, food (M=1.70) makes the biggest, and transportation (M= 0.17) makes the smallest contribution to the ecological footprint of the pre-service science teachers (M=3.91). However, housing (M=1.01) and goods/services (M=1.03) effect the ecological footprint at very similar levels. The average ecological footprint of the pre-service science teachers is 3.91 global hectares, which is more than the average ecological footprint of Turkey (total 2.7 global hectares according to Living Planet Report (2008). While average global footprint is 2.7 global hectares per-capita in the world, pre-service science teachers have an ecological footprint of 1.21 global hectares. This situation indicates that pre-service science teachers will need two worlds more to maintain their lifestyles in this way. No pre-service science teacher participating in the research had a private car; all of them use mass transportation, hence, the ecological footprint turned out to be smallest in the transportation category.

After sustainable life education

After the sustainable life education, pre-service science teachers were asked the question, "What is the ecological Footprint? Define it in your own words?" Post-study views of the pre-service science teachers on this subject are shown in Table II collecting them in the associate categories.

Table II. *The Views of Pre-service Science Teachers about the Ecological Footprint Concept*

Categories	***% (Percentage)***
The total effect of human on the world	36
Biologically productive land and water areas required to produce all the resources an individual consumes and to absorb the waste they generate	24
Intuitional measurement of the effect of individual/society on nature	19
Indicator of sustainability	3
Environment policy and the calculation instrument used for environmental management	3
Others	15

* Students gave answers, which were included in more than one per category.

Some of the expressions of the pre-service teachers which are under the category of "the total effect of the human being on the world" are as follows:

16th person: "The load that the individuals living in the society leave on the world is called the ecological footprint. In the other words, the effects of people on the environment."

25th person: "The total of the positive and negative effects of the living beings while they maintain their lives is called the ecological footprint."

33rd person: "The mathematical expression of the total effect of using material and energy and harmful wastes that living beings give to nature; in brief, all effects of the living beings that maintain their life on nature. The effect is the print that human beings leave in the nature."

49th person: "The total effect of the wastes that human beings take from the nature and give back through consumption is called the ecological footprint."

Some of the views of the pre-service science teachers that participated in the research under the category of "biologically productive land and water area

required to produce all the resources an individual consumes and to absorb the waste they generate" are as follows:

1st person: "It is the product that human beings use from their birth until their death and the biological area that is necessary to absorb the wastes of these products."

13th person: "We can say the area of nature of the human beings use. The footprint, which humans should have in the world, has been calculated by dividing the total usable productive area in the world by the total population. But the footprints of the countries show that in the near future the world cannot be enough for us anymore."

35th person: "The measure that shows the biological area someone uses considering the production and consumption of this person on the world."

41st person: "The ecological footprint is the biological area that is required for consumption and the wastes caused by consumption. The ecological footprint of someone is the measurement that shows the required biological area for life profile."

Some of the expressions of the pre-service science teachers participated in the research, which are under the category of "intuitional measurement of the effect of individual/society on nature":

6th person: "The ecological footprint, however, is a measure indicating that some ecological limitations are a criterion that guides us to have sustainable lifestyles."

10th person: "It is the examination of the production and consumption possibilities of a human being on the world and the measurement of the harm human beings on nature."

27th person: "In brief, we can say it is a measurement and an instrument that is used to measure the impact of human beings on nature. Our ecological footprint is bigger if we harm the environment more. If we adopt a sustainable life model, our ecological footprint can diminish and we can become friendly toward the environment."

30th person: "We can express it as the load that human beings impose on the nature because of their consumption habits."

41st person: "The ecological footprint of someone is the measurement that shows the required biological area for their life profile."

Some of the expressions of the pre-service science teachers who participated in the research are under the category of "environment policy and the calculation instrument used for environment management":

3rd person: "The footprint, which humans should have in the world, has been calculated dividing the total usable productive area on the world by the total population. However, the footprints of countries show that in the near future the world cannot be enough for us anymore. The ecological footprint is actually a calculation instrument that is used by countries for their environmental management and policies."

38th person: "Thanks to ecological the footprint we can measure how much nature we use. In this manner, the countries can determine their environmental policies."

Some of the expressions of the pre-service teachers who participated in the research are under the category of "indicator of sustainability":

12th person: "An ecological footprint is the indicator of the sources that a person produces and consumes and that includes the total impacts of the person on the world and therefore on sustainability of the life"

43rd person: "It is the indicator of how harmful or how beneficial we are to our environment. In the other words, it is the indicator of how sustainable we use nature."

Some of the expressions of the pre-service teachers participated in the research, which are under the category of "other":

2nd person: "It is the total of the contacts of a human being with nature in his life. The water he pollutes, the water he wastes, and the flower he picks up in park are included in this concept."

4th person: ".Our consumption habits determine our ecological footprint. And the wastes we produce increase our ecological footprint."

18th person: "It is the thing that human beings take from the nature and leave in the nature"

19th person: "...our consumption habits and lifestyles determine our ecological footprint."

43rd person: "...our place in the nature."

45th person: "The natural sources human beings consume and the wastes they leave in nature."

Conclusion and Discussion

This study provides insight into the effectiveness of teaching sustainable living courses in higher education. Encouragingly, most of pre-service science teachers identified valid features of an ecological footprint. Having said that, some features of the findings clearly indicate areas where further learning would be beneficial.

It is concluded that food makes the biggest and that transportation makes the smallest contribution to the ecological footprint of the pre-service science teachers. However, housing and goods/services affect ecological footprint in very similar levels. The ecological footprints of the pre-service science teachers turned out to be more than the ecological footprint of the world per-capita. This situation showed that the pre-service science teachers should make important changes in their lifestyles in order to diminish their ecological footprints. Furthermore, this situation underlies the importance of the negative impacts that the pre-service science teachers impose on the world.

While the results of the study indicate that the greatest contribution to the ecological footprints of the pre-service science teachers comes from the food component, Janis (2007) in a study among the students of Ohio University, reported that the greatest contribution comes from the energy and transportation component. In a study carried out by Akilli et al. (2008) among the students of Akdeniz University, the students' footprint was found to be 4.52 hectares, and the greatest contribution was due to the wastes component.

It is remarkable that the pre-service teachers had no idea on this concept before the research. In most countries, the ecological footprint analysis that is considered to be

the indicator of the sustainable life was known approximately 14 years ago; it was not known by the pre-service science teachers who participated in the research in Turkey. This demonstrates there is a significant backwardness in our country in this area. This study is important to reveal these shortcomings, even if it is for a small sample.

It was observed that vocabularies of the pre-service science teachers developed, and their vision got richer after the research. The pre-service science teachers have become aware of their negative effects on the world. In addition, they noticed we have to give back to nature what we take from it. They noticed that unless we give back what we take from the nature, there would not be a biological area to live on any more. This circumstance has been effective for the pre-service science teachers to digitally learn the impact of their lifestyles on sustainable life. Generally we use phrases like, "we harm, we pollute," while we mention the impacts of human beings on the nature, but we cannot answer the questions, "How much do we pollute? How much will we harm?" Because the concept of the ecological footprint uncovers our impact on the nature and shows us concrete values, it is effective to develop sustainable standards. In this way, the pre-service science teachers who were educated will demonstrate this knowledge and their manners at schools where they will teach; and hence, these pre-service science teachers will play an important role in maintaining the future of our world in the sustainable life area. Ryu & Brody (2006) found that sustainable behaviours that can be measured with an ecological footprint show positive changes, and this concurs with our finding. Keles (2007) reported that when the ecological footprint is used as an educational tool, the participants' awareness of and attitudes and behaviours towards sustainable life exhibited positive changes. Wada, Izumi & Mashiba (2007) reported that ecological footprint is an effective instrument in changing our lifestyles and providing ecological sustainability, and Wackernagel & Rees (1996) state that through in-school and out of-school activities (for example, work on energy and matter flow in nature, doing experiments related to sustainable lifestyle and supporting the simultaneously taught mathematics, biology and physics courses with concrete local applications) the concept of footprint should be consolidated. This study provided insight into how pre-service students feel about environmental sustainability and the need to take action for reducing ecological footprint. Sustainable living applications should be carried out at other levels of education with different variables. Additional research is needed to determine if graduate

courses can produce permanent alterations in lifestyle or if they have only a short-lived effect.

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