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Evaluation of Barriers to Implementation of Environmental Education with Fuzzy FUCOM Technique

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Abstract

In this study, in order to examine the significance and encourage the adoption of Environmental Education (EE), it is fundamentally important to determine the strength and levels of the obstacles encountered in the EE process and to present the proposed solution. First of all, with the literature review, the factors that were found to affect the EE process in the past studies were determined. Then, a new subjective weighting method called the fuzzy Full Consistency Method (FUCOM) was used to determine the criterion weights of the obstacles. The final values of the weight coefficients were obtained using the GAMS/CPLEX package program. As a result of the application, it was determined that the most important obstacles encountered during the implementation of EE are financial inadequacies, lack of transportation, safety, responsibility, and classroom management, lack of content information, and lack of natural science knowledge. Based on the findings obtained in the last part of the study, recommendations were made for the dissemination of EE.

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1. Introduction

As a result of the increasing awareness of the masses, awareness of environmental problems has increased rapidly in recent years. In addition, the connection between people and the environment has been interrupted due to reasons such as population growth and urbanization. Population growth and urbanization have propelled human beings to destroy the natural environment in their quest to create more places for habitation. Trees and forests have been destroyed, mountains and hills are leveled, waterways have been redirected, water areas have been filled, and were all built by humans for habitation and comforts. However, re-establishing the connection with natural areas and obtaining information about the environment will cause the balance of human beings with nature to be re-established (Bruyere, Wesson, & Teel, 2012). Environmental Education (EE) has the potential to facilitate the connection between humans and nature. And will create that environmental awareness that would make everyone a major contributor towards solving, together, the environmental problems.

The concept of EE was introduced to promote knowledge, create awareness, improve attitudes, acquire skills, and engage in the participation needed to address global environmental problems such as biodiversity loss, food shortages, pollution, and health problems (Anderson & Jacobson, 2018). Seeking to create sustainable relationships between the environment and people, EE is recognized as an international pedagogical trend (Ravindranath, 2007). The United Nations Educational Scientific and Cultural Organization (UNESCO) (1978) report on EE's aims and objectives clearly defined the importance of ecological interactions in urban and rural systems, awareness of various experiences in the environment, and providing students with basic ecological knowledge.

EE is a process that enables individuals to explore environmental issues, participate in problem-solving and take action to improve the environment (Environmental Protection Agency (EPA), 2021). The Environmental Protection Agency (EPA) defined the components of EE as follows; awareness and sensitivity towards the environment, knowledge, and understanding of the environment, attitudes towards environmental problems, and the ability to help solve environmental problems. However, the concept of EE can also be defined as a permanent investment to create a sustainable society (Ravindranath, 2007). Despite these definitions accepted in the literature, the current status, curriculum guidelines, and scope of EE vary by country, region, and even school.

Despite the recognition of its current benefits, there are many barriers to integrating EE into educational settings; the school curriculum. Despite well-intentioned efforts on a local, regional and global scale, (to enhance EE) barriers to EE still exist (Anderson & Jacobson, 2018). The slow progress of EE, especially in public schools, can be attributed to many different reasons (Ham, Rellergert-Taylor, & Krumpe, 1988). In a study by Sewing (1986), barriers to EE were classified into four categories. These obstacles are, Conceptual Barriers stemming from the lack of consensus on the scope of EE, Logistical Barriers stemming from perceived time, funding, and teaching resources, Educational Barriers stemming from instructors' qualifications, and Attitudinal Barriers stemming from trainers' attitudes towards EE. There is a need to focus on identifying and elaborating the barriers to EE. Thus, the impact levels of barriers will be reduced and it will be easier to show more interest in EE, especially in public schools.

Identifying the barriers to EE and analyzing the degree of importance of these barriers have strategic importance in integrating the process into the education curriculum. In many studies in the literature, the problems encountered in the transition to EE and during the application process have been examined. In the current study, the degree of importance of these obstacles was determined using the fuzzy Full Consistency Method (FUCOM). The criteria analyzed in the study were determined as a result of a systematic and detailed literature review. The criteria were examined in four dimensions: Attitudinal, Conceptual, Educational, and Logistical. A total of four main criteria and sixteen sub-criteria were analyzed.

In the literature review conducted in the current study, many studies were identified in which the obstacles encountered in the EE process were examined using qualitative and quantitative techniques. However, no study was found in which multi-criteria decision-making methods were used. The current study, it is aimed to propose an original approach that will contribute to the understanding of the problems encountered in the process, encourage future research that will use different techniques, and contribute to the literature on the subject with the findings of the study.

2. Literature Review

In many recent studies, the attitudes of students, educators, and school administrators on EE have been analyzed. In these studies, the obstacles to EE were examined and recommendations for improving the current situation were presented. The perspectives of all actors on EE in the process, the determination of the perceived difficulties, the preparations for integrating EE concepts into the teaching process, the level of use of the concept of EE in education, and the examination of the factors that motivate the actors to EE are the main study areas on the subject.

In the current study, the studies in the literature in which the obstacles encountered in the transition to EE are analyzed by qualitative and quantitative methods. At the end of this analysis process, the criteria to be used in practice were determined in Table 1. The main studies on the subject in the literature are presented in this part of the study.

In the study conducted by Ham and Sewing (1988), personal interviews were conducted with classroom teachers to determine the barriers and relative importance of EE in public schools in the USA. The results showed that the lack of time for both the school day and preparation was the most serious obstacle. Cherif (1992) analyzed the barriers to ecology education in North American high schools and presented steps that could help improve the state of ecology education. Malone (1992) examined the concerns expressed by the teachers in the process of applying EE to classroom programs. Thirteen teachers working in four schools in Australia participated in the data collection process. Lin (1993) aimed to determine the relative importance of factors that prevented British Columbian public school teachers from conducting EE in eighth, ninth, and tenth grades. In the study, interviews were conducted with fifty-one secondary school teachers from four different schools. Robertson and Krugly-Smolska (1997) examined teachers' perspectives on EE and the difficulties they perceived while presenting environmental programs with a qualitative study. Smith-Sebasto and Smith (1997) evaluated public school teachers' preparations to integrate EE concepts into their teaching, their attitudes towards EE, and the extent to which they used EE concepts in their teaching. Simmons (1998) aimed to identify the factors that motivate teachers to use various natural environments for EE. In the study, teachers were asked to evaluate different outdoor environments, perceived benefits, and barriers.

Fisher (2001) examined how changes in the UK education system affected fieldwork. The study identifies the factors that undermine the position of the fieldwork and analyzes the potential consequences of large-scale organizational change in schools. Talsma (2001) analyzed a school-based EE program called the Rouge Education Project. In the study, the difficulties encountered during the execution of the program, the level of participation, and the changes it created were examined. Ardoin and Sivek (2002) used in-depth interviews, surveys, and primary and secondary source reviews to identify EE needs in Nicaragua and compile information on current EE programs. Easton and Monroe (2002) analyzed instructors' use of project activities, their use in school curricula, and the obstacles they encountered during the activity in the Project Learning Tree perspective, a widely used EE program in Florida. Monroe (2002) conducted a needs assessment process with undergraduate students in an EE program development course at Florida University. The study aimed to determine the attitudes of teachers toward EE and to evaluate their needs for EE services. Zint, Kraemer, Northway, and Lim (2002) evaluated the Chesapeake Bay Foundation's conservation education programs. The

study was aimed to determine to what extent the participants supported environmentally responsible behaviors and to determine the obstacles that teachers encountered in teaching. Cutter-Mackenzie and Smith (2003) investigated Australian primary school teachers' knowledge of EE. In the study, a combined methods approach was used to evaluate primary school teachers' knowledge and beliefs.

Table 1. Barriers encountered in the environmental education process.

Main Criteria	Sub-criteria	Reference
Attitudinal (C_a)	Lack of teacher motivation (C_{a1})	El-Batri, Alami, Zaki, and Nafidi (2019), Evans, Whitehouse, and Gooch (2012), Gilbert (2019), Story (2019)
	Lack of student interest (C_{a2})	Anderson and Jacobson (2018), Cutter-Mackenzie (2010), Fisher (2001), Gilbert (2019), Kralovicova (2020), Zint, Kraemer, Northway, and Lim (2002)
	Lack of administrative support (C_{a3})	Ernst (2009), Evans et al. (2012), Gilbert (2019), Ruether (2018)
	Lack of parental support (C_{a4})	Ernst (2009), Malone (1992)
Conceptual (C_b)	Curriculum issues (C_{b1})	El-Batri et al. (2019), González-Gaudiano (2007), Kralovicova (2020), Reese (2019)
	Identification issues (C_{b2})	Anderson and Jacobson (2018), Bruyere et al. (2012), Cherif (1992), Evans et al. (2012),
	Lack of consensus (C_{b3})	Evans et al. (2012), Robertson and Krugly-Smolska (1997), Talsma (2001)
	Failure to understand the purpose of EE (C_{b4})	Cherif (1992), Fisher (2001), Ginsburg and Audley (2020), Robertson and Krugly-Smolska (1997), Simmons (1998)
Educational (C_c)	Lack of content information (C_{c1})	Anderson and Jacobson (2018), Ernst (2007), Ernst (2009), Ham and Sewing (1988), Kralovicova (2020), Smith-Sebasto and Smith (1997), Zint, Kraemer, Northway, and Lim (2002)
	Lack of pedagogical knowledge (C_{c2})	Ernst (2007), Ernst (2009), Ham and Sewing (1988)
	Lack of natural science knowledge (C_{c3})	Lin (1993), Ham and Sewing (1988), Ruether (2018)
Logistical (C_d)	Lack of teaching materials (C_{d1})	Anderson and Jacobson (2018), Carrier, Tugurian, and Thomson (2013), El-Batri et al. (2019), Ham and Sewing (1988), Robertson and Krugly-Smolska (1997), Smith-Sebasto and Smith (1997), Zint, Kraemer, Northway, and Lim (2002)
	Financial inadequacies (C_{d2})	Anderson and Jacobson (2018), Ardoin and Sivek (2002), Bruyere et al. (2012), Kralovicova (2020), Lin (1993), Ernst (2007), Ernst (2009), Evans et al. (2012), Ham and Sewing (1988), Reese (2019), Ruether (2018), Smith-Sebasto and Smith (1997), Story (2019), Talsma (2001), Zint, Kraemer, Northway, and Lim (2002)
	Safety, responsibility, and classroom management (C_{d3})	Anderson and Jacobson (2018), El-Batri et al. (2019), Ernst (2007), Ernst (2009), Fisher (2001), Ham and Sewing (1988), Kralovicova (2020), Simmons (1998)
	Lack of transportation (C_{d4})	Ernst (2007), Ernst (2009), Ham and Sewing (1988), Kralovicova (2020), Story (2019)
	Lack of time (C_{d5})	Ardoin and Sivek (2002), Evans et al. (2012), Ham and Sewing (1988), Kralovicova (2020), Lin (1993), Story (2019)

Ernst (2007) conducted an exploratory survey with a sample of 287 teachers to encourage wider adoption of the environmental-based education approach and to investigate the environmental-based education capabilities of teachers. Analysis of variance and discriminant function analysis were used in the study. González-Gaudiano (2007) examined the difficulties and resistances that the transition to EE faced in Latin American education systems and emphasized the inadequacy of the traditional school curriculum to respond to today's conditions. Sosu, McWilliam, and Gray (2008) aimed to examine the important factors that determine teachers' commitment to EE and discover ways to increase their commitment to EE. Ernst (2009) conducted interviews with eighth-grade teachers teaching in public schools to evaluate the benefits obtained from environmental-based education and the obstacles encountered in the process.

Cutter-Mackenzie (2010) discusses the broad impact of school-based EE programs from the Waste Wise Schools program perspective. A state-wide assessment questionnaire was presented to primary and secondary

school teachers in the study. Moseley, Huss, and Utley (2010) aimed to observe the change in EE competence beliefs as a result of teachers' use of the "Global Learning and Observations to Benefit the Environment" curriculum. Bruyere et al. (2012) examined the process of integrating EE into an after-school program in New York. In this qualitative case study, focus group interviews were conducted to identify parents' and educators' interest in incorporating EE into the curriculum. Evans et al. (2012) interviewed the principals and staff of two regional primary schools operating in Australia to examine the barriers to sustainable education and the methods adopted to overcome them. Data collected from managers and key personnel were subjected to a qualitative categorical analysis. Adams (2013) investigated how teachers overcome the factors that prevent the integration of EE into public school classrooms. Data for this qualitative research were collected through observations, interviews and collection of documents. Carrier, Tugurian, and Thomson (2013) examined the science learning and outdoor teaching experiences of fifth-grade students. A mixed-method study aiming to identify the difficulties encountered in the process of incorporating EE into primary school science teaching and to understand students' attitudes towards the environment is presented.

Kinder et al. (2015) aimed to observe the changes in knowledge and attitude caused by short-term field trips. For this reason, some tests were conducted on fourth-year students who participated in a short field trip at the US Forest Service Campsite. Ashfaq and Mujtaba (2016) aimed to explore the defining barriers of EE in Pakistan and remedies for alleviating these barriers. In the study, interviews designed based on different dimensions related to EE were conducted to obtain complete information from the participants. Anderson and Jacobson (2018) identified 48 barriers to EE reported by educators in the global literature and compared these barriers with empirical data collected from rural Ecuador. To identify and classify the barriers, 25 trainers from 6 schools were interviewed and the Q methodology was used. Ruether (2018) conducted a qualitative study to determine whether life experiences affect a teacher's choice of using environmentally-based education and to identify barriers to using environmentally-based education in outdoor classrooms. El-Batri et al. (2019) examined the status of environmental activities carried out by 48 environmental clubs belonging to the urban and rural areas of Morocco. In the study, the main barriers to reaching certain environmental activities were identified, and the significant correlations detected between some of the variables examined provided a better explanation of the successes and weaknesses of these clubs. Gilbert (2019) aimed to investigate the factors that hinder the successful implementation of EE practice in Kenya. For this purpose, the effects of teachers' and students' attitudes, administrative support, and curriculum design on EE practice were examined. Reese (2019) aimed to explore the factors that positively or negatively affect student access to a community-based outdoor EE organization called Children's Forest in the USA. Story (2019) analyzed barriers and incentives for participation in EE field trips in the Congaree Biosphere Reserve. Ginsburg and Audley (2020) investigated the knowledge of preschool teachers about sustainable education in the current curriculum to identify the barriers to sustainable education in early childhood. For this purpose, twenty-two early childhood educators and administrators working in nine education centers operating in the USA were interviewed. In the study conducted by Kralovicova (2020) the existing obstacles to the implementation of EE were examined through interviews and questionnaires with teachers. The teacher-focused study was concluded with semi-structured interviews completed with Q-Methodology. In the literature review, it was determined that the barriers to the EE process were examined through various methods, including student or teacher interviews, questionnaires, and focus groups. The common point of the studies carried out is to understand the existing obstacles to the development and facilitation of EE and to try to obtain findings for overcoming these obstacles. Despite a large number of studies on the subject, no study has been found in which the barriers and the degree of importance of these obstacles are analyzed by multi-criteria decision-making methods. This study is aimed to present an original approach to help understand the obstacles encountered in the EE process and to encourage new researchers and contribute to the literature with the data obtained.

3. Methodology

FUCOM, which was introduced to the literature by Pamučar, Stević, and Sremac (2018) is a decision-making technique that aims to determine criterion weights and is based on the principles of pairwise comparisons of criteria and validation of results along with the deviation from maximum consistency. The method compares the importance of all components at a certain hierarchical level and satisfies the consistency conditions. The FUCOM technique, which significantly eliminates the shortcomings of BWM and AHP methods, does not have the problem of redundancy of pairwise comparisons of criteria. The FUCOM method, which uses only exact numbers, was adapted to fuzzy sets by Pamucar and Ecer (2020), and the FUCOM-F method was developed. The steps adopted in the present study are given below.

Step 1. After the criteria and sub-criteria are determined, the criteria are ranked according to their appropriate importance levels.

Step 2. The criteria are compared with each other using a fuzzy pairwise comparison scale Table 2. Then, the comparative preference of the criteria is obtained using Equation 1.

Table 2. Fuzzy pairwise comparison scale.

Linguistic variable	l_{ij}
Equally important (E)	(1; 1; 1)
Weakly important (W)	(0.667; 1; 1.5)
Fairly important (F)	(1.5; 2; 2.5)
Very important (V)	(2.5; 3; 3.5)
Absolutely important (A)	(3.5; 4; 4.5)

$$\widetilde{\Phi}_{k/(k+1)}=\frac{\widetilde{w}_{C_{j(k+1)}}}{\widetilde{w}_{C_{j(k)}}}=\frac{\widetilde{w}^{l}_{C_{j(k+1)}},\widetilde{w}^{m}_{C_{j(k+1)}}\widetilde{w}^{u}_{C_{j(k+1)}}}{\widetilde{w}^{l}_{C_{j(k)}},\widetilde{w}^{m}_{C_{j(k)}}\widetilde{w}^{u}_{C_{j(k)}}} \quad (1)$$

Step 3. The final values of the fuzzy weight coefficients of the criteria are calculated. The final values of the weight coefficients should satisfy the conditions given in Equation 2 and Equation 3.

$$\frac{w_k}{w_{k+1}}=\Phi_{k/(k+1)} \quad (2)$$

$$\frac{w_k}{w_{k+2}}=\Phi_{k/(k+1)}\cdot\Phi_{(k+1)/(k+2)} \quad (3)$$

Equation 3 emphasizes transitivity. Maximum consistency is met only when fully adhered to transitivity. To satisfy the maximum consistency requirement, the value of χ must be minimised and conditions $\left|\frac{w_{j(k)}}{w_{j(k+1)}}-\Phi_{k/(k+1)}\right|\le\chi$ and $\left|\frac{w_{j(k)}}{w_{j(k+2)}}-\Phi_{k/(k+1)}\cdot\Phi_{(k+1)/(k+2)}\right|\le\chi$ must be satisfied. In order to determine the optimal fuzzy values of the weight coefficients of the evaluation criteria, the nonlinear model given in Equation 4 is established.

$$\begin{aligned}&\min\ \chi\\&\text{Constraints:}\\&\left|\frac{\widetilde{w}_{j(k)}}{\widetilde{w}_{j(k+1)}}-\Phi_{k/(k+1)}\right|\le\chi,\ \forall\text{j}\\&\left|\frac{\widetilde{w}_{j(k)}}{\widetilde{w}_{j(k+2)}}-\Phi_{k/(k+1)}\cdot\Phi_{(k+1)/(k+2)}\right|\le\chi,\ \forall\text{j}\\&\sum_{j=1}^{n}\widetilde{w}=1,\ \forall\text{j}\\&w_j^l\le w_j^m\le w_j^u\\&w_j^l\ge 0,\ \forall\text{j}\\&\text{j}=1,2,\ldots,\text{n}\end{aligned} \quad (4)$$

Conditions $\frac{w_{j(k)}}{w_{j(k+1)}}-\Phi_{k/(k+1)}=0$ and $\frac{w_{j(k)}}{w_{j(k+2)}}-\Phi_{k/(k+1)}\cdot\Phi_{(k+1)/(k+2)}=0$ must be met for the highest consistency. Thus, the model given in Equation 4 is transformed into the fuzzy linear model presented in Equation 5. As a result of solving the model, optimal fuzzy values of coefficients are obtained.

$$\begin{aligned}&\min\ \chi\\&\text{Constraints:}\\&\left|w_k-w_{k+1}\otimes\Phi_{k/(k+1)}\right|\le\chi,\ \forall\text{j}\\&\left|w_k-w_{k+2}\otimes\Phi_{k/(k+1)}\otimes\Phi_{(k+1)/(k+2)}\right|\le\chi,\ \forall\text{j}\\&\sum_{j=1}^{n}\widetilde{w}=1,\ \forall\text{j}\\&w_j^l\le w_j^m\le w_j^u\\&w_j^l\ge 0,\ \forall\text{j}\\&\text{j}=1,2,\ldots,\text{n}\end{aligned} \quad (5)$$

In the established model, expressions are presented in the form of $\widetilde{w}_j=(w_j^l,w_j^m,w_j^u)$ and $\widetilde{\Phi}_{k/(k+1)}=(\widetilde{\Phi}^l_{k/(k+1)},\widetilde{\Phi}^m_{k/(k+1)},\widetilde{\Phi}^u_{k/(k+1)})$.

Step 4. The outputs obtained as a result of the solution of the model give the triangular fuzzy coefficient values of each criterion. These values are converted to net weights via Equation 6 ($a_j=(l_j,m_j,u_j)$).

$$\text{R}(a_j)=(l_j+4m_j+u_j)/6 \quad (6)$$

The final weights of the criteria are obtained as a result of converting the fuzzy values to exact numbers. The criterion with the highest weight is the criterion with the highest relative importance. The criteria are ranked by their weight.

4. Application

In this part of the study, the obstacles to the EE process were evaluated using the fuzzy FUCOM technique. The criteria evaluated in the study were examined in four dimensions: attitudinal, conceptual, educational, and logistical. In the study, a total of 4 main criteria and 16 sub-criteria were analyzed. The steps adopted in the Implementation section are given.

Step 1. The criteria and sub-criteria to be used in the application are presented in Table 1. The order of the criteria according to their degree of importance is given in Table 3.

Table 3. Ranking of criteria according to their importance level.

Criteria type	Ranking of the criteria
Main criteria	$C_d>C_b>C_c>C_a$
C_a	$C_{a3}>C_{a2}>C_{a2}>C_{a4}$
C_b	$C_{b2}>C_{b1}>C_{b4}>C_{b3}$
C_c	$C_{c1}>C_{c3}>C_{c2}$
C_d	$C_{d2}>C_{d4}>C_{d3}>C_{d1}>C_{d5}$

Step 2. Pairwise comparisons of the criteria reached using Table 2 are presented in Table 4. After that, the comparative preferences of the criteria are calculated via Equation 1.

Table 4. Pairwise comparisons of criteria.

Criteria type	Pairwise comparisons			
Main Criteria	C_d-C_b	C_b-C_c	C_c-C_a	-
	V	W	E	-
C_a	C_{a3}-C_{a1}	C_{a1}-C_{a2}	C_{a2}-C_{a4}	-
	F	E	W	-
C_b	C_{b2}-C_{b1}	C_{b1}-C_{b4}	C_{b4}-C_{b3}	-
	E	W	E	-
C_c	C_{c1}-C_{c3}	C_{c3}-C_{c2}	-	-
	W	A	-	-
C_d	C_{d2}-C_{d4}	C_{d4}-C_{d3}	C_{d3}-C_{d1}	C_{d1}-C_{d5}
	W	W	F	E

Using Equation 1, the comparative preferences of the main criteria were calculated as given.

$\widetilde{\Phi}_{d/b} = \widetilde{w}_{C_d}/\widetilde{w}_{C_b} = (2.5; 3; 3.5) / (1; 1; 1) = (\frac{2.5}{1}; \frac{3}{1}; \frac{3.5}{1}) = (2.5; 3; 3.5)$

$\widetilde{\Phi}_{b/c} = \widetilde{w}_{C_b}/\widetilde{w}_{C_c} = (0.667; 1; 1.5) / (2.5; 3; 3.5) = (\frac{0.667}{3.5}; \frac{1}{3}; \frac{1.5}{2.5}) = (0.191; 0.333; 0.6)$

$\widetilde{\Phi}_{c/a} = \widetilde{w}_{C_c}/\widetilde{w}_{C_a} = (1; 1; 1) / (0.667; 1; 1.5) = (\frac{1}{1.5}; \frac{1}{1}; \frac{1}{0,667}) = (0.667; 1; 1.5).$

Thus, the preference vectors for the main criteria, attitudinal, conceptual, educational and logistical criteria are as follows.

$\widetilde{\Phi}_{Main\ Criteria} = ((2.5; 3; 3.5), (0.191; 0.333; 0.6), (0.667; 1; 1.5))$

$\widetilde{\Phi}_a = ((1.5; 2; 2.5), (0.4; 0.5; 0.667), (0.667; 1; 1.5))$

$\widetilde{\Phi}_b = ((1; 1; 1), (0.667; 1; 1.5), (0.667; 1; 1.5))$

$\widetilde{\Phi}_c = ((0.667; 1; 1.5), (2.333; 4; 6.747))$

$\widetilde{\Phi}_d = ((0.667; 1; 1.5), (0.445; 1; 2.249), (1; 2; 3.748), (0.4; 0.5; 0.667))$

Step 3. The fuzzy weight coefficients of the criteria are calculated by applying Equation 2 and Equation 3. The calculation procedures for the values for the main criteria are given.

$\widetilde{w}_{C_d}/\widetilde{w}_{C_c} = \widetilde{w}_{C_d}/\widetilde{w}_{C_b} \cdot \widetilde{w}_b/\widetilde{w}_{C_c} = (2.5; 3; 3.5), (0.191; 0.333; 0.6) = (0.478; 1; 2.1)$

$\widetilde{w}_{C_b}/\widetilde{w}_{C_a} = \widetilde{w}_{C_b}/\widetilde{w}_{C_c} \cdot \widetilde{w}_c/\widetilde{w}_{C_a} = (0.191; 0.333; 0.6), (0.667; 1; 1.5) = (0.127; 0.333; 0.9)$

The coefficient values of the attitude, conceptual, educational and logistical criteria are presented below.

$\widetilde{W}_{C_{a_3}}/\widetilde{W}_{C_{a_2}} = (0.6; 1; 1.668)$; $\widetilde{W}_{C_{a_1}}/\widetilde{W}_{C_{a_4}} = (0.267; 0.5; 1)$
$\widetilde{W}_{C_{b_2}}/\widetilde{W}_{C_{b_4}} = (0.667; 1; 1.5)$; $\widetilde{W}_{C_{b_1}}/\widetilde{W}_{C_{b_3}} = (0.445; 1; 2.25)$
$\widetilde{W}_{C_{c_1}}/\widetilde{W}_{C_{c_2}} = (1.556; 4; 10.121)$
$\widetilde{W}_{C_{d_2}}/\widetilde{W}_{C_{d_3}} = (0.297; 1; 3.374)$; $\widetilde{W}_{C_{d_4}}/\widetilde{W}_{C_{d_1}} = (0.445; 2; 6.429)$; $\widetilde{W}_{C_{d_3}}/\widetilde{W}_{C_{d_5}} = (0.4; 1; 2.5)$

Based on the calculated data, models were created for all criteria by means of Equation 5 to determine the fuzzy optimal value of the weighting coefficients. The model created for the main criteria is given.

$$\min \chi$$

Constraints:

$$\left(w_d^l - 2.5w_b^u\right) \le \chi \quad \left(w_b^u - 0.6w_c^l\right) \le \chi \quad \left(w_d^m - w_c^m\right) \le \chi$$
$$\left(w_d^l - 2.5w_b^u\right) \ge -\chi \quad \left(w_b^u - 0.6w_c^l\right) \ge -\chi \quad \left(w_d^m - w_c^m\right) \ge -\chi$$
$$\left(w_d^m - 3w_b^m\right) \le \chi \quad \left(w_c^l - 0.667w_a^u\right) \le \chi \quad \left(w_d^u - 2.1w_c^l\right) \le \chi$$
$$\left(w_d^m - 3w_b^m\right) \ge -\chi \quad \left(w_c^l - 0.667w_a^u\right) \ge -\chi \quad \left(w_d^u - 2.1w_c^l\right) \ge -\chi$$
$$\left(w_d^u - 3.5w_b^l\right) \le \chi \quad \left(w_c^m - w_a^m\right) \le \chi \quad \left(w_b^l - 0.127w_a^u\right) \le \chi$$
$$\left(w_d^u - 3.5w_b^l\right) \ge -\chi \quad \left(w_c^m - w_a^m\right) \ge -\chi \quad \left(w_b^l - 0.127w_a^u\right) \ge -\chi$$
$$\left(w_b^l - 0.191w_c^u\right) \le \chi \quad \left(w_c^u - 1.5w_a^l\right) \le \chi \quad \left(w_b^m - 0.333w_a^m\right) \le \chi$$
$$\left(w_b^l - 0.191w_c^u\right) \ge -\chi \quad \left(w_c^u - 1.5w_a^l\right) \ge -\chi \quad \left(w_b^m - 0.333w_a^m\right) \ge -\chi$$
$$\left(w_b^m - 0.333w_c^m\right) \le \chi \quad \left(w_d^l - 0.478w_c^u\right) \le \chi \quad \left(w_b^u - 0.9w_a^l\right) \le \chi$$
$$\left(w_m^b - 0.333w_c^m\right) \ge -\chi \quad \left(w_d^l - 0.478w_c^u\right) \ge -\chi \quad \left(w_b^u - 0.9w_a^l\right) \ge -\chi$$
$$(w_a^l + 4w_a^m + w_a^u)/6 + (w_b^l + 4w_b^m + w_b^u)/6 + (w_c^l + 4w_c^m + w_c^u)/6 + (w_d^l + 4w_d^m + w_d^u)/6 = 1$$
$$w_a^l \le w_a^m \le w_a^u; w_b^l \le w_b^m \le w_b^u; w_c^l \le w_c^m \le w_c^u; w_d^l \le w_d^m \le w_d^u$$
$$w_a^l, w_a^m, w_a^u, w_b^l, w_b^m, w_b^u, w_c^l, w_c^m, w_c^u, w_d^l, w_d^m, w_d^u \ge 0$$

Step 4. The application of the model is solved through the GAMS/CPLEX package program. The triangular fuzzy coefficient values obtained in the solution of the model are converted to net weights using Equation 6. The final criteria weights calculated are given in Table 5.

Table 5. Final weights of criteria.

Criteria	Weights of the criteria	Criteria	Weights of the criteria
C_{a1}	0.036	C_{c1}	0.073
C_{a2}	0.036	C_{c2}	0.019
C_{a3}	0.058	C_{c3}	0.071
C_{a4}	0.034	C_{d1}	0.067
C_{b1}	0.058	C_{d2}	0.146
C_{b2}	0.058	C_{d3}	0.083
C_{b3}	0.056	C_{d4}	0.084
C_{b4}	0.056	C_{d5}	0.067

As a result of the application, it was determined that the most important obstacle in front of EE is financial inadequacies. The obstacles with the highest weight coefficient are listed as financial inadequacies, lack of transportation, safety, responsibility, and classroom management, lack of content information, and lack of natural science knowledge.

5. Conclusion

Many factors affect the successful implementation of EE and the conditions that create perceptions about EE. There are many obstacles that students, teachers, and educational institutions face in the implementation of EE, and these obstacles reduce the motivation of all actors in the process. To change the environmental behavior of the next generation in a positive sense and with a sense of responsibility, it is necessary to carry out EE and solve the obstacles encountered in the process. In the current study, it is expected to identify the obstacles in front of EE, analyze the importance of these obstacles, and characterize the current situation. A result of this analysis is aimed to encourage all actors in the process about EE.

As a result of the analysis, it was discovered that the biggest obstacles in front of EE are financial inadequacies and lack of transportation. Governments and Educational Institutions play a vital role in solving these barriers. Government and Educational Institutions should adopt EE as part of the curriculum, incorporate

it into their financial strategies, and set policies for corporate social responsibility. An innovative strategy needs to be presented, emphasizing financial and transport requirements, to promote effective EE. In addition, local actors, non-governmental organizations, and educational institutions should cooperate to focus on overcoming these shortcomings and encouraging local action.

Other important obstacles in front of EE are safety, responsibility, and classroom management, lack of content information, and lack of natural science knowledge. There is a need to focus on the depth of teachers' understanding of national EE policies and their level of competence. Developing regionally oriented teacher competence, together with enhanced pre-service and in-service training, will yield beneficial results. This process can be carried out with a formal program with medium and long-term goals. Increasing teachers' competence in the subject will significantly improve students' active participation in studying local environmental problems and their motivation to adopt pro-environmental behaviors.

In the current study, not all of the obstacles that may be encountered in the EE process have been addressed. In future studies, the factors preventing environmental participation can be analyzed by focusing only on parent and student-oriented problems. However, the existing list of criteria can be enriched with different dimensions, as perspectives on barriers vary. In addition, in a different study, focusing on teacher competencies in the implementation of EE in schools is a research topic that will contribute to the literature.

In the research, the fuzzy FUCOM technique was used to determine the degree of importance of the problems encountered in the EE process. In the literature, the importance levels of the criteria are determined through various weighting methods. The research, it is aimed to overcome the problems involving uncertainty by integrating the FUCOM technique with fuzzy set theory. The model proposed in future research can also be used for different fields of science. In addition, the fuzzy FUCOM method used in criterion weighting can be used with different ranking methods to decide the best alternative in multi-criteria decision-making problems.

In the study, the areas that need to be taken into account to ensure the use of EE as a more widespread teaching approach and to facilitate its implementation are revealed. The results of the study were expected to encourage the execution of the EE process and guide the design of the process. The findings obtained in the research, it is aimed to provide information that will help all actors in the process cope with the difficulties they face.

References

Adams, T. R. (2013). *Overcoming barriers to teaching action-based environmental education: A multiple case study of teachers in the public school classroom.* Masters Theses, Western Kentucky University.

Anderson, C., & Jacobson, S. (2018). Barriers to environmental education: How do teachers' perceptions in rural Ecuador fit into a global analysis? *Environmental Education Research*, *24*(12), 1684-1696.Available at: https://doi.org/10.1080/13504622.2018.1477120.

Ardoin, N. M., & Sivek, D. J. (2002). Environmental education needs assessment study in the Carazo department of Nicaragua. *Applied Environmental Education and Communication: An International Journal*, *1*(4), 235-244.Available at: https://doi.org/10.1080/15330150290106185.

Ashfaq, S., & Mujtaba, G. (2016). Barriers to environmental education and remedies in Pakistan. *International Journal of Ethics in Social Sciences*, *4*(1), 41-50.

Bruyere, B. L., Wesson, M., & Teel, T. (2012). Incorporating environmental education into an urban after-school program in New York City. *International Journal of Environmental and Science Education*, *7*(2), 327-341.

Carrier, S. J., Tugurian, L. P., & Thomson, M. M. (2013). Elementary science indoors and out: Teachers, time, and testing. *Research in Science Education*, *43*(5), 2059-2083.Available at: https://doi.org/10.1007/s11165-012-9347-5.

Cherif, A. H. (1992). Barriers to ecology education in North American high schools are another alternative perspective. *The Journal of Environmental Education*, *23*(3), 36-46.Available at: https://doi.org/10.1080/00958964.1992.9942800.

Cutter-Mackenzie, A. (2010). Australian waste wise schools program: Its past, present, and future. *The Journal of Environmental Education*, *41*(3), 165-178.Available at: https://doi.org/10.1080/00958960903347471.

Cutter-Mackenzie, A., & Smith, R. (2003). Ecological literacy: The 'missing paradigm in environmental education (part one). *Environmental Education Research*, *9*(4), 497-524.Available at: https://doi.org/10.1080/1350462032000126131.

Easton, J., & Monroe, M. C. (2002). Project learning tree teacher assessment survey. *Applied Environmental Education and Communication: An International Journal*, *1*(4), 229-234.Available at: https://doi.org/10.1080/15330150290106167.

El-Batri, B., Alami, A., Zaki, M., & Nafidi, Y. (2019). Extracurricular environmental activities in Moroccan middle schools: Opportunities and challenges to promoting effective environmental education. *European Journal of Educational Research*, *8*(4), 1013-1028.Available at: https://doi.org/10.12973/eu-jer.8.4.1013.

Environmental Protection Agency (EPA). (2021). What is environmental education? https://www.epa.gov/education/what-environmental-education. [Accessed 01 November 2021].

Ernst, J. (2007). Factors associated with K-12 teachers' use of environment-based education. *The Journal of Environmental Education*, *38*(3), 15-32.Available at: https://doi.org/10.3200/joee.38.3.15-32.

Ernst, J. (2009). Influences on US middle school teachers' use of environment-based education. *Environmental Education Research*, *15*(1), 71-92.Available at: https://doi.org/10.1080/13504620802710599.

Evans, N., Whitehouse, H., & Gooch, M. (2012). Barriers, successes and enabling practices of education for sustainability in far North Queensland schools: A case study. *The Journal of Environmental Education*, *43*(2), 121-138.Available at: https://doi.org/10.1080/00958964.2011.621995.

Fisher, J. A. (2001). The demise of fieldwork as an integral part of science education in United Kingdom schools: A victim of cultural change and political pressure? *Pedagogy, Culture, and Society*, *9*(1), 75-96.Available at: https://doi.org/10.1080/14681360100200104.

Gilbert, C. M. (2019). *Barriers to implementation of environmental education in secondary schools in Molo, Nakuru County, Kenya.* Doctoral Dissertation, Kenyatta University.

Ginsburg, J. L., & Audley, S. (2020). You don't wanna teach little kids about climate change: Beliefs and barriers to sustainability education in early childhood. *International Journal of Early Childhood Environmental Education, 7*(3), 42-61.

González-Gaudiano, E. (2007). Schooling and environment in Latin America in the third millennium. *Environmental Education Research, 13*(2), 155-169.Available at: https://doi.org/10.1080/13504620701295684.

Ham, S. H., Rellergert-Taylor, M. H., & Krumpe, E. E. (1988). Reducing barriers to environmental education. *The Journal of Environmental Education, 19*(2), 25-33.

Ham, S. H., & Sewing, D. R. (1988). Barriers to environmental education. *The Journal of Environmental Education, 19*(2), 17-24.Available at: https://doi.org/10.1080/00958964.1988.9942751.

Kinder, T., Mesner, N. O., Larese-Casanova, M., Lott, K. H., Cachelin, A., & LaLonde, K. (2015). Changes in knowledge and attitude from a short-term aquatic education program. *Natural Sciences Education, 44*(1), 18-25.Available at: https://doi.org/10.4195/nse2014.10.0024.

Kralovicova, B. (2020). *Teaching comes naturally–or does it?: Environmental education in Indian primary schools and the impediments of its application from teachers' perspectives.* Doctoral Dissertation, Lund University.

Lin, E. S. (1993). *Barriers to environmental education in British Columbia.* Doctoral Dissertation, University of British Columbia.

Malone, K. (1992). *Teachers' concerns about implementing environmental education through their classroom programs.* Doctoral Dissertation, Cowan University.

Monroe, M. C. (2002). Assessing teachers' needs for environmental education services. *Applied Environmental Education and Communication: An International Journal, 1*(1), 37-43.Available at: https://doi.org/10.1080/15330150213988.

Moseley, C., Huss, J., & Utley, J. (2010). Assessing K–12 teachers' personal environmental education teaching efficacy and outcome expectancy. *Applied Environmental Education and Communication, 9*(1), 5-17.Available at: https://doi.org/10.1080/15330150903566398.

Pamucar, D., & Ecer, F. (2020). Prioritizing the weights of the evaluation criteria under fuzziness: The fuzzy full consistency method–FUCOM-F. *Facta Universitatis, Series: Mechanical Engineering, 18*(3), 419-437.Available at: https://doi.org/10.22190/fume200602034p.

Pamučar, D., Stević, Ž., & Sremac, S. (2018). A new model for determining weight coefficients of criteria in modem models: Full consistency method (FUCOM). *Symmetry, 10*(9), 393.Available at: https://doi.org/10.3390/sym10090393.

Ravindranath, M. (2007). Environmental education in teacher education in India: Experiences and challenges in the United Nation's decade of education for sustainable development. *Journal of Education for Teaching, 33*(2), 191-206.Available at: https://doi.org/10.1080/02607470701259481.

Reese, R. F. (2019). A qualitative exploration of the barriers and bridges to accessing community-based K-12 outdoor environmental education programming. *Journal of Outdoor and Environmental Education, 22*(1), 21-37.Available at: https://doi.org/10.1007/s42322-018-0019-4.

Robertson, C. L., & Krugly-Smolska, E. (1997). Gaps between advocated practices and teaching realities in environmental education. *Environmental Education Research, 3*(3), 311-326.Available at: https://doi.org/10.1080/1350462970030305.

Ruether, S. (2018). *Barriers to teachers' use of environmentally-based education in outdoor classrooms.* Doctoral Dissertation, Walden University.

Sewing, D. R. (1986). *Barriers to environmental education: Perceptions of elementary teachers in the Palouse Region of Washington and Idaho.* Doctoral Dissertation, University of Idaho.

Simmons, D. (1998). Using natural settings for environmental education: Perceived benefits and barriers. *The Journal of Environmental Education, 29*(3), 23-31.Available at: https://doi.org/10.1080/00958969809599115.

Smith-Sebasto, N. J., & Smith, T. L. (1997). Environmental education in Illinois and Wisconsin: A tale of two states. *The Journal of Environmental Education, 28*(4), 26-36.Available at: https://doi.org/10.1080/00958964.1997.9942833.

Sosu, E. M., McWilliam, A., & Gray, D. S. (2008). The complexities of teachers' commitment to environmental education: A mixed-methods approach. *Journal of Mixed Methods Research, 2*(2), 169-189.Available at: https://doi.org/10.1177/1558689807313163.

Story, T. (2019). *Barriers and facilitators to engagement with environmental education field trips in the Congaree biosphere reserve: A spatial perspective.* Doctoral Dissertation, Clemson University.

Talsma, V. (2001). The rouge education project: Challenges of implementation. *The Journal of Environmental Education, 32*(3), 26-30.Available at: https://doi.org/10.1080/00958960109599142.

United Nations Educational Scientific and Cultural Organization (UNESCO). (1978). Paper presented at the Intergovernmental Conference on Environmental Education Organized ByUnesco in Co-Operation with Unep (Tbilisi, Ussr, 14-26 October 1977). Final Report.

Zint, M., Kraemer, A., Northway, H., & Lim, M. (2002). Evaluation of the Chesapeake bay foundation's conservation education programs. *Conservation Biology, 16*(3), 641-649.Available at: https://doi.org/10.1046/j.1523-1739.2002.00546.x.