

Article

Massive Open Online Education for Environmental Activism: The Worldwide Problem of Marine Litter

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Abstract: (1) The amount of plastic discharges in the environment has drastically increased in the last decades negatively affecting aquatic ecosystems, societies, and the world economy. The policies initiated to deal with this problem are insufficient and there is an urgency to initiate local actions based on a deep understanding of the factors involved. (2) This paper investigates the potential of massive open online courses (MOOCs) to spread environmental education. Therefore, the conclusions drawn from the implementation of a MOOC to combat the problem of marine litter in the world are presented. (3) This work describes the activity of 3632 participants from 64 countries taking an active role presenting useful tools, connecting them with the main world associations, and defining applied action plans in their local area. Pre- and post-questionnaires explore behavioral changes regarding the actions of participants to combat marine litter. The role of MOOCs is contrasted with social media, formal education, and informal education. (4) Findings suggest that MOOCs are useful instruments to promote environmental activism, and to develop local solutions to global problems, for example, clean beaches, supplanting plastic bottles, educational initiatives, and prohibition of single-use plastic.

Keywords: action-based learning; digital media; environmental perspective; leadership development; MOOC; social interaction; technological changes

1. Introduction

The amount of plastic litter discharged in the environment has drastically increased over the last decades [1,2]. The use of plastic has transformed how many objects in our daily life are manufactured and packaged. One of the main characteristics of plastics is its durability. Almost all the plastic that has been created over the past 70 years still persists in some form at present [3]. Marine litter is among the main threats to biological diversity due to its abundance and persistence in the marine environment. Marine life faces an enormous threat caused by the millions of tons of plastic waste that end up in the oceans each year [4–7]. It was found that more than 693 animal species are being affected by marine litter, of which 17% are on the International Union for Conservation of Nature (IUCN) Red list of threatened species [4]. Microplastics are nowadays found in oceans and sediments worldwide [8,9]. Because of the increasing amounts of microplastics and plastics in the environment there are serious concerns about the effects on marine ecosystems, human health [10,11], and food safety [12].

It was estimated that until 2017 there would have been 8300 tons (Mt) of plastic, of which approximately 9% has been recycled, 12% has been incinerated and 79% would persist in the environment [2–4]. Rochman concluded that if the current trends of a 5% production increase per

year continues, an additional 33 billion tons of plastic will pile up around the globe by 2050 [13]. Plastic pollution is even greater in developing countries, mostly because of a lack of the necessary waste management infrastructure [2,14–16].

Although the range of effective solutions has significantly increased over the last years, there are still many gaps to fill [17]. Worldwide there are many initiatives aiming at plastic pollution and several sustainable development goals also target marine litter pollution. Marine litter pollution is a complex environmental problem which involves many stakeholders. Higher education for sustainable development is also aiming at the complexity of environmental problems and the global perspective of responsibility [18].

Massive open online courses (MOOCs) are a new form of e-learning offering multiple courses run by universities all around the world. Many academics become interested in MOOCs recognizing their potential to offer environmental education for sustainability [19–21] on an unprecedented scale [22,23]. In addition, the proliferation of mobile devices in recent years is facilitating access to educational content [24–27] especially increasing participation in developing countries where there is neither habit nor infrastructures to manage waste properly [2]. The problem of marine litter is global and must be addressed via education and awareness [28,29]. A recent project in the form of a practical education course allowed undergraduate students in Connecticut to raise awareness about the problem by collecting marine litter locally, and creating a report that would later be handed out to local policy makers. Students experienced statistically significant improvements in knowledge and behavior variables but they also made their work public [30].

1.1. Research Problem

Education is a useful tool to address this global problem from an early age. Young people cannot only change their habits with relative ease, but they are also capable of transmitting this awareness to their families and broader communities working as catalysts for change [29]. On the other hand, pro-environmental strategies are frequently connected to political strategies [31,32]. Therefore, it is crucial that educators acknowledge the serious and sometimes fatal risks of taking political action while encouraging the potential of people to make change through critically-focused educational activist work [33]. The power of education is key and can be more effective than strict laws. An example is the “Plastics Law of Suffolk County” in New York, where retail food packaging prohibition did not succeed in reducing waste on their beaches [34]. Thinking globally and acting locally is a fundamental attitude to reduce this threat to the environment. Therefore, in this work, MOOCs are studied as a massive tool focused on action, to explore and disseminate ways of tackling the global problem of marine litter from an educational perspective.

The Open University of the Netherlands (OUNL) and the United Nations Environment (UN Environment) have partnered for the development of MOOC on Marine Litter targeting the following variety of sectors and stakeholders: governments, people responsible for formulating policies; private companies, non-governmental and intergovernmental organizations; civil society; and the academic world. MOOCs were developed to stimulate leadership and to offer opportunities for learning aimed at changing habits. MOOCs sought to empower the participants with the necessary skills to address the complex difficulties surrounding marine litter which include: the identification and reduction of sources of marine litter; the quantification of the environmental, economic and social impacts of marine litter; the documentation of risks and identification of efficient solutions; and the dissemination of good and innovative practices aimed at mitigating this global problem.

MOOCs aimed to instigate participants to take an active role in the treatment of marine litter by providing in-depth knowledge, sharing useful tools, and connecting participants with the main networks in the world currently working on this problem.

1.2. Goals and Research Questions

The aim of this research is to examine the potential of MOOCs to foster environmental transformation based on the implementation of a MOOC to promote environmental activism and to combat the problem of marine litter in the world. Therefore this study investigates the following research questions (RQ):

- RQ1: What are the goals of participants in a MOOC towards taking action against the worldwide problem of marine litter?
- RQ2: What actions do MOOC participants take in digital media to face the worldwide problem of marine litter? What is the influence of digital media to promote real actions to combat marine litter in contrast to alternative factors (e.g., formal education or the education given by parents at home)?
- RQ3: What is the potential of MOOCs to foster environmental activism combating the worldwide problem of marine litter?
- RQ4: The MOOCs on Marine Litter comprise different digital instruments such as videos, interactive maps, social networks, group tasks or discussion forums. Which of these instruments have more potential to promote actions to combat marine litter?
- RQ5: What specific actions of environmental transformation can be created and disseminated in a MOOC?

The following section describes how the study was conducted. Section 3 presents the results obtained in the study. In Section 4, the results which were analyzed targeting the previously listed research questions are presented.

2. Materials and Methods

This research was carried out in the context of the MOOC on Marine Litter organized by the United Nations Environment and the Open University of the Netherlands between January and May 2018. To the best of our knowledge, this course is the first MOOC to combat the problem of marine litter in the world. The MOOC on Marine Litter applied action-oriented learning in order to teach how to apply actions to combat marine litter in a student's own local environment, regardless of their profession or location. The course presented different tools to combat marine pollution, revealing a series of initiatives that are currently being implemented to inspire leadership, initiate actions, increase awareness, and stimulate creative solutions to address the problems of marine litter.

This MOOC comprised of 8 blocks that were progressively released one by one each week. The MOOC was offered in two possible specializations: (1) a leadership track which included the first 2 blocks, (2) an expert tack which included all of the 8 blocks. In both specializations, the teaching load was divided into a theoretical part and a practical activity. The students obtained a "certificate of leadership" and/or a "certificate of expertise" accredited by the UN Environment and OUNL when they completed the practical activity after the second and the eighth block, respectively. For this task learners were assigned to analyze a plastic pollution case study using the DPSIR model (driving forces, state, pressures, impacts and responses) [35]. The DPSIR model is an adaptive management tool useful to analyze environmental problems and to identify potential answers [36,37]. In addition, it is a useful tool to initiate actions focused on sustainable development. In this MOOC, the DPSIR facilitated students to review and structure the main global problems of marine litter.

2.1. Participants

The study included 3632 students registered in the Spanish language MOOC on Marine Litter, 65.2% (n = 2168) were women, the mean age was M = 40.1 years with a standard deviation SD = 11.7. The participants who completed the course were connected from 64 different countries. Mexico 18.9% (n = 687), Brazil 17.5% (n = 639), Spain 14.5% (n = 529), Peru 9.8% (n = 358), Chile 5.6% (n = 204), Colombia 5.4% (n = 197), Argentina 4.7% (n = 172), Portugal 3.2% (n = 118) and Ecuador 2.8% (n = 105) registered the largest number of participants.

The results reported to the question “Which role fits you best combating marine litter in media (channels)?” are summarized in Table 1. The results showed that more than 75% of the participants were “consumers” of digital news, TV, and radio. These percentages were more balanced between “consumer” and “contributor” in social networks, Internet, blogs, and specialized websites ranging from 31.32% to 54.91%. The higher rate of “producers” seemed to be more active in social networks (21.12%).

Table 1. Which role fits you best combating marine litter in media (channels)? (n = 1098).

Digital Media	Consumer	Contributor	Producer
Digital news	77.68% (853)	16.48% (181)	5.64% (62)
TV	83.15% (913)	10.65% (117)	6.10% (66)
Radio	79.87% (877)	13.20% (145)	6.83% (75)
Social networks	41.34% (454)	37.43% (411)	21.12% (232)
Internet, blogs, and specialized websites	54.91% (603)	31.32% (344)	13.57% (149)

2.2. Materials and Design

This course was implemented on the Open edX platform, a non-profit online initiative that offers courses from relevant universities in the world [38]. With the open source vision, Open edX is freely available to the community so that any institution can deploy its own instance of Open edX and offer its own courses.

Each block of the MOOC contained 2 to 4 learning sequences (Figure 1) guiding the participants through learning resources such as videos, texts, discussion forums, interactive maps, and self-assessment exercises. The participants were expected to design and upload a local action plan at the end of each track. Every week an e-mail was sent to participants to alert them when a new block was released. This notification also included answers to frequently asked questions solved in the discussion forums during the previous week.

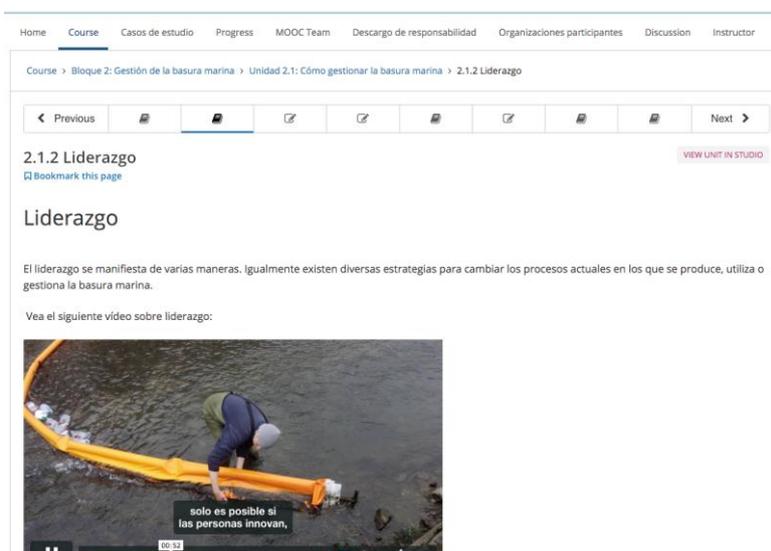


Figure 1. Block 2, sequence 1, learning resource 2: Leadership cleaning beaches.

2.3. Mesasure Instruments

The links which included the invitations to participate in the pre-questionnaire and post-questionnaire were sent to the users by e-mail one week before the beginning of the MOOC and one week after completing the MOOC respectively. In addition, a reminder to complete the questionnaires was sent two weeks after the first invitation. The questionnaire consisted of a self-constructed survey comprising 23 items thereof 5 were intended to define personal profile (age, gender, demographics etc.), 8 were intended to explore

student environmental activism, and 10 were intended to explore research questions that are not relevant for this paper. Regarding the items dealing with environmental activism, 7 5-likert-scale questions were included in order to explore the participants' agreement (3 items) with predefined statements and the participants' perceived importance of specific channels and features (4 items). A multiple-choice question prompted students to select 1 option among 4 different alternative ranges of dates.

The results of the questionnaires were imported from the online survey platform to MS Excel format and later exported to CSV format to be analyzed in R-Studio.

A Twitter account and a Facebook group were opened for participants to contact each other using alternative channels that might be more familiar to them. In addition, the participants had discussion forums on the platform where they could discuss the suggested case studies, raise questions, and organize themselves to carry out the final works.

Practical works resulting from both the leadership and the expert tracks were analyzed. Significant actions to combat marine litter were spotted based on the documented case studies and action plans.

3. Results

This section describes the actions of environmental activism identified as a consequence of analyzing (1) the results of a pre- and post-questionnaire, (2) case studies and action plans designed in practical assignments, and (3) the activity reported by the participants in their own social networks.

The results of pre- and post-questionnaires collected in the MOOC are used to explore its potential towards environmental activism. A total of 1098 students voluntarily accepted the proposal to participate in this research completing the pre-questionnaire and signing the informed consent. The average age of the participants was $M = 32.9$ years with a standard deviation $SD = 11.2$. A total of 121 students completed the post-questionnaire when the MOOC was finished. The average age of the participants was $M = 37.3$ years with a standard deviation $SD = 12.3$. The rest of the demographics are presented in Table 2.

Table 2. Demographics.

Participants	% (n)
Pre-questionnaire	1098
Country	
México	27.4% (301)
Spain	16.3% (179)
Brazil	15.6% (172)
Perú	6.9% (76)
Chile	5.55% (61)
Colombia	5.19% (57)
Argentina	4.73% (52)
Other countries	18.21% (200)
Gender	
Female	65.5% (719)
Male	34.5% (379)
Studies	
Higher university	40.6% (446)
Master's degree	22.1% (243)
Higher non-university	15.7% (173)
Secondary education	11.7% (129)
Doctoral studies	4.4% (49)
Post-questionnaire	121
Gender	
Female	63% (76)
Male	37% (45)

3.1. Environmental Activism Before the MOOC

3.1.1. Previous Experience in MOOCs

Two questions were raised to explore students' previous experience in other MOOCs (n = 1098):

The first question asked, "How many MOOCs have you participated in so far?" and the mean resulted in $M = 1.04$ and the standard deviation was $SD = 1.64$.

For the second question participants were asked to specify, "How did you come to know about the MOOC on Marine Litter?" and the results to the question are presented in Table 3.

Table 3. How did you come to know about the MOOC? (n = 1098).

Option	% (n)
By chance navigating Internet	32.0% (352)
Someone I know recommended me to try them	28.8% (317)
I explored searching online courses and I found them	13.9% (153)
A coworker advised me	5.1% (56)
I knew them at my own university	3.8% (42)
They came up in some conversation I do not remember	3.5% (39)
MOOCs become part of the formal studies in which I was enrolled	3.4% (38)
I knew of them in journals and specialized publications	2.1% (24)
Other	7.0% (77)

3.1.2. Expectations

Participants were asked to report their initial expectations regarding environmental activism as a consequence of participating in the MOOC. Hence, participants had to specify their goals answering Yes or No to a list of alternative options. The option "explore possibilities to work with other organizations on the problem of marine litter" was selected by 679 (61.8%) of the participants, followed by "explore possibilities to work with other people on the problem of marine litter" by 555 (50.5%) of the participants, "extend my network of contacts in the matter" by 436 (39.7%) of the participants, and finally "share my knowledge" by 382 (34.7%) of the participants.

3.1.3. Potential of Education and Digital Media towards Environmental Activism

The following question aimed to explore the potential of digital media, education, and MOOCs to encourage actions to combat the problem of marine litter. Cronbach's alpha was calculated to test the reliability of the dataset with regards to the potential of the tools listed in Table 4 towards environmental activism. The scores obtained demonstrated adequate internal consistency of scores with $\alpha = 0.84$. Scores 0.80 or higher were considered a good reliability.

Table 4 summarizes the results reported by the participants classified into "digital media" and "education" in decreasing order of the mean values. Regarding the digital media classification, "social networks", "Internet blogs", and "specialized web pages" obtained the highest values, as compared with "radio", "digital news", and "TV" that obtained the lowest values. Regarding the education classification, "family education at home" obtained the higher values as compared with formal education alternatives, in other words, school, university, and MOOCs.

The last question in the pre-questionnaire asked participants to quantify the age they considered most appropriate for education on the cause of combating marine litter and 51% (n = 561) reported between 0 and 10 years, 42% (n = 460) between 20 and 30 years, 5% (n = 55) after 30 years.

Table 4. What is the potential of these tools to foster real actions to combat the problem of marine litter? (n = 1098).

Tool	Very Important (5)	Important (4)	Moderate Importance (3)	Somewhat Important (2)	Not Important (1)	M (SD)
Digital media						
Social networks	81.69% (897)	12.30% (135)	3.01% (33)	1.18% (13)	1.73% (19)	4.70 (0.75)
Internet, blogs and specialized pages	67.94% (746)	27.77% (250)	6.10% (67)	1.46% (16)	1.64% (18)	4.53 (0.82)
TV	67.49% (741)	20.86% (229)	6.65% (73)	3.10% (34)	1.82% (20)	4.48 (0.89)
Digital news	39.53% (434)	34.24% (376)	19.85% (218)	4.92% (54)	1.37% (15)	4.05 (0.96)
Radio	38.71% (425)	34.34% (377)	18.94% (208)	5.83% (64)	2.09% (23)	4.01 (1.00)
Education						
Family	86.36% (980)	7.92% (87)	1.46% (16)	0.46% (5)	0.91% (10)	4.83 (0.56)
School and university	87.45% (960)	9.20% (101)	1.73% (19)	0.64% (7)	1.0% (11)	4.80 (0.62)
MOOC	67.49% (741)	25.87% (284)	5.56% (61)	0.46% (5)	0.46% (5)	4.59 (0.68)

3.2. Environmental Activism During the MOOC

Four items in the pre- and post-questionnaires aimed to explore whether students' participation in the MOOC might influence their capacity to combat the worldwide problem of marine litter.

3.2.1. Perceived Activism

The question "Do you consider yourself an active person in the cause of combating marine litter?" aimed at contrasting significant mean differences between the pre- (n = 1098) and the post- (n = 121) questionnaire. Participants reported they considered themselves to be slightly more active in the cause of combating marine litter in the post-questionnaire M = 4.2 (SD = 0.90) as compared with the pre-questionnaire M = 4.1 (SD = 0.85).

Since answers to the questionnaires are not paired because they are anonymous, the Shapiro–Wilk test was used to determine the normality of the sample. The Shapiro–Wilk test resulted in a *p*-value <0.05. The distribution of the data differs significantly from the normal distribution, and therefore the normality of the data cannot be assumed. The Wilcoxon test is a nonparametric test that allows the comparison of two groups of independent samples in which their data are not normally distributed. The Wilcoxon test resulted in a *p*-value below alpha value = 0.05, which indicates significant differences between the means obtained before and after the MOOC.

3.2.2. Addressing the Problem of Marine Litter

Table 5 summarizes the results reported by the participants in the pre-questionnaire (n = 1098) and the post-questionnaire (n = 121) to the question "Do you think this MOOC will help you on the following matters of importance to address the problem of marine litter?" which aimed to identify significant mean differences before and after participating in the course. The response "digitally connect people involved in actions to combat marine litter" obtained the higher agreement (M = 4.23) in the pre-questionnaire (n = 1098) followed by "disseminate existing actions to foster participation", "start individual and local actions", "spread enthusiasm", and "develop a collective intelligence". All mean values slightly decreased in the post-questionnaire (n = 121) ranging from 0.08 to 0.20.

Cronbach's alpha was calculated to test the reliability of the dataset with regard to the importance of the factors listed in Table 5 with respect to addressing the problem of marine litter. The scores obtained demonstrated very good internal consistency of scores with $\alpha = 0.97$. Scores 0.90 or higher are considered as very good reliability. The Shapiro–Wilk test resulted in a *p*-value <0.05 in all cases, implying that the distribution of the data significantly differs from the normal distribution. Hence, the normality of the data cannot be assumed. The Wilcoxon test is a nonparametric test that

allows the comparison of two groups of independent samples in which their data are not normally distributed. The p -value above $\alpha = 0.05$ indicates that there were no significant differences between the means obtained in the pre-questionnaire and the post-questionnaire.

Table 5. Do you think this MOOC will help you on the following matters of importance to address the problem of marine litter? pre-questionnaire (n = 1098) and post-questionnaire (n = 121).

	Test	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	ShW p	Wcx p	M (SD)
Digitally connect people involved in actions to combat marine litter	Pre	54.19% (595)	32.33% (355)	4.10% (45)	1.46% (16)	7.83% (86)	$p < 0.05$	$p = 0.05$	4.23 (1.14)
	Pos	45.45% (55)	37.19% (45)	4.96% (6)	0% (0)	12.40% (15)			4.03 (1.27)
Disseminate existing actions to foster participation	Pre	48.91% (537)	37.80% (515)	3.73% (41)	1.91% (1)	7.56% (83)	$p < 0.05$	$p = 0.05$	4.18 (1.12)
	Pos	40.50% (49)	42.15% (51)	3.31% (4)	1.65% (2)	12.40% (15)			3.96 (1.27)
Start individual & local actions	Pre	7.72% (524)	37.07% (407)	5.83% (64)	1.64% (18)	7.65% (84)	$p < 0.05$	$p > 0.05$	4.15 (1.13)
	Pos	42.15% (51)	37.19% (45)	4.96% (6)	3.31% (4)	12.40% (15)			3.93 (1.31)
Spread enthusiasm	Pre	46.54% (511)	36.52% (401)	7.10% (78)	2.09% (23)	7.65% (84)	$p < 0.05$	$p > 0.05$	4.11 (1.14)
	Pos	47.11% (57)	33.88% (41)	4.96% (6)	2.48% (3)	11.57% (14)			4.02 (1.29)
Develop a collective intelligence	Pre	42.90% (471)	40.53% (445)	6.74% (74)	2.00% (22)	7.74% (85)	$p < 0.05$	$p > 0.05$	4.08 (1.13)
	Pos	46.28% (56)	33.88% (41)	5.79% (7)	2.48% (3)	11.57% (14)			4.00 (1.29)

ShW: Shapiro–Wilk Test, Wcx: Wilcoxon Test.

3.2.3. Digital Tools Comprising the MOOC

The following questions were aimed at exploring the potential of the digital tools comprising the MOOC to encourage real actions to combat marine litter. The Cronbach's alpha was calculated to test the reliability of the dataset with regard to the potential of the digital tools listed in Table 6 towards addressing the problem of marine litter. The scores obtained demonstrated very good internal consistency of scores with $\alpha = 0.97$.

Table 6. Potential of digital tools within the MOOC (post-questionnaire N = 121).

Digital Tools	Very Important (5)	Important (4)	Moderate Importance (3)	Somewhat Important (2)	Not Important (1)	M	SD
Videos	64.46% (78)	25.62% (31)	5.79% (7)	2.48% (3)	1.65% (2)	4.48	0.91
Projects world map from marine litter network	54.55% (66)	30.58% (37)	10.74% (13)	2.48% (3)	1.65% (2)	4.34	0.89
Text content	55.37% (67)	32.23% (39)	5.79% (7)	4.96% (6)	1.65% (2)	4.34	0.91
Individual tasks	36.36% (44)	46.28% (56)	9.92% (12)	4.13% (5)	3.31% (4)	4.08	0.96
Forums	33.88% (41)	42.15% (51)	14.05% (17)	7.44% (9)	2.48% (3)	3.97	1.00
Task in groups	33.60% (40)	42.15% (51)	17.36% (21)	4.13% (5)	3.31% (4)	3.97	0.98
Dissemination and interactions in Facebook	27.27% (33)	37.19% (45)	18.83% (24)	11.57% (14)	4.13% (5)	3.71	1.11
Dissemination and interactions in Twitter	25.62% (31)	32.23% (39)	25.62% (31)	10.74% (13)	5.79% (7)	3.61	1.15

3.2.4. Individual Initiatives

The last question in the post-questionnaire explored whether participants had initiated real actions to combat marine litter as a consequence of their participation in the MOOC and 66% (n = 55) of the participants answered affirmatively. In addition, they were asked to describe what actions they had taken into practice:

- Participant#7 reported “organizing cleanups and training divers to collect garbage”;
- Participant#51 reported she had “installed trash cans on beaches and making signs to raise awareness”;
- Participants#5, #18 and #21 reported they were “participating in the cleanup of beaches, rivers, and natural spaces”;
- Participants#6 and #25 reported they had “contributed to chats and campaigns for awareness in educational centers”;
- Student#31 stated “he would try to raise awareness among family and friends about marine debris”;
- Students#50 and #2 reported having stopped using single-use plastic bottles.

3.2.5. Analysis of Case Studies: Driving Forces, State, Pressures, Impacts and Responses

Finally, 208 case studies were analyzed and submitted in the leadership track. Experts in marine litter participating in this MOOC highlighted the following case studies based on depth and quality of the analysis according to the model:

- Case study#43 suggested an intervention in a fishing village aimed at making teachers and students in primary schools aware of the local problem of solid marine litter as well as educating on sustainable consumption habits for the environment;
- Case study#121 was a social initiative that aimed at minimizing or prohibiting the use, sale, and production of plastic bags in a city;
- Case study#12 aimed at providing instruction on how to recycle fishing nets thrown into the sea.
- In case study#88 the “scientists of the garbage” designed a program that aimed at bringing schools into science focusing on the problem of marine litter. The plan comprised education on scientific methods, promoted respect for the environment, and generated strategies to reduce garbage in the environment;
- Awareness case study#64 entitled “take three!” suggested students at an educational center collect three daily units of garbage and share the photo on social networks. They also organized a weekly “day without plastic” to promote actions within an interest group to collect waste.

3.2.6. Design an Action Plan

Students in the expert track were guided to introduce themselves in the platform’s forum and to present action plans towards working in groups of four to 10 people. The activity suggested participants form groups around a specific theme (i.e., recycling plastic waste, educate children) or location (i.e., Costa Dorada, Rio de Janeiro). Once participants had voluntarily formed into groups, participants were invited to use alternative channels they might find more practical to communicate (e.g., skype, e-mail, Facebook, Whatsapp), and to engineer a real action plan using the DPSIR model.

Finally, 95 students completed the task and obtained a certificate. Experts in marine litter participating in this MOOC highlighted the following action plans based on their affordability and novelty:

- Plan#11 documented a wastewater treatment plan for seaports;
- The action plan#17 entitled “free plastic party” proposed to schedule short interventions within music festivals, boat parties, gastronomic events, and mass parties where huge amounts of waste are generated, to raise awareness of the problem;

- Plan#18 comprised an educational plan for primary schools to incorporate a compulsory subject where children would be taught what is happening in the oceans to raise their awareness that plastic does not disappear;
- Plan#29 promoted regulatory changes in the use of municipal beaches with regard to the prohibition of throwing cigarette butts and the declaration of “beaches without smoke”.

Once the course had finished, participants were encouraged to put their action plans into practice in their local environment. More in-depth global marine litter problems structured according to the DPSIR framework, including some examples of common measures and main geographical focus areas are reported in [17].

3.3. Environmental Actions After the MOOC

The MOOC on Marine Litter offered alternative channels to connect participants in social networks as well as to report actions and denunciations to combat the marine litter in the world. It was also intended to connect leaders, actors, students or anyone involved in combatting this problem to initiate real actions once the course had finished. A Facebook group, a Twitter account and a public wall (Padlet) were enabled. The interactions in these media offered a window to visualize and disseminate individual and group actions to deal with a global problem when the MOOC was finished. This section highlights some of the most relevant actions based on an analysis performed three months after finishing the MOOC:

- Beaches: A group of activists “friends of sea” took the initiative to put a poster on the beach stating “Save your beach’s life. Take the garbage with you” (See Figure 2a) to urge tourists at Costa de Oro in Uruguay, to take a reusable plastic bag with them to keep the garbage they might generate. They also demanded not throwing cigarette butts.
- In-land actions: A group of students from the Faculty of Civil Engineering in Madrid “paths without plastics” launched a challenge to avoid the consumption of single-use plastics on the campus. Among other actions, they put on sale metal bottles at an economical price, with the aim of supplanting the consumption of bottled water in single-use plastic. Under this challenge, the students shared experiences where they asked for the fruit and cutlery in the dining room not to be wrapped in plastic. This challenge has been further extended to other campuses within the university.
- Field trips: Social networks in this MOOC echoed the message of “Volunteers for the Ocean in Chile” and announced a calendar of dates and beaches to be used by volunteers who could join to clean up the waste (Figure 2c). This proposal followed up with further groups in Brazil, Mexico, and Peru publishing similar messages to act on their local beaches.
- Sports: Social networks facilitated that fans of minority sports (i.e., diving, canoeing) could synchronize participants in a certain place and time to join forces and take actions. The “marine watchers in Seville” group annually mobilizes a thousand volunteers to clean garbage on the Spanish coast under the slogan “the sea is not the carpet that hides everything” (Figure 2b). Another action around sports was a group of volunteers who proposed canoe trips for the collection of plastics.
- Governmental activities: Social networks in this MOOC spread ongoing measures at the governmental level in different regions and countries. The coastal municipalities of Araucanía in Chile took the initiative to work on regulations for the prohibition of single-use plastic bags. Another case is that of the United Kingdom where the microplastics in cosmetics have been banned, since these type of particles usually end up in the oceans where they cause damage to fauna and flora, and can ultimately be ingested by humans.
- Events and conferences: Thanks to the interactions carried out in social networks, participants in this MOOC group were able to publicize events and conferences to combat the marine litter problem. The Plastic Oceans Foundation of Chile publicized the poster for its conference “Rethinkplastic 2018” where challenges, visions and multisectorial solutions were sought to stop

plastic pollution in Chile. Another example was the “I Days of Citizen Science” on the beaches of Noja in Cantabria (Spain).

In general, participants in the MOOC were very active by sending impacting photos about the effects of marine litter, publicizing their initiatives, and disseminating local technological advances (i.e., the first machine in the world to remove plastics from the ocean).



Figure 2. Actions for environmental transformation shared in social networks (a) friends of the sea (Costa de Oro, Uruguay); (b) marine watchers (Seville, Spain); and (c) volunteers for the ocean (Coquimbo, Chile).

4. Discussion

This work discusses the potential of MOOCs to stimulate global environmental transformation actions. The course pursues sustainable actions to motivate participants to act locally to combat a global problem such as marine litter. To the best of our knowledge, the course analyzed in this paper is the first massive open online course tackling environmental problems in the context of marine litter, as well as identifying their potential responses. Five research questions have guided this research.

Research question one was aimed at exploring the initial goals of participants in the MOOC towards taking action against the worldwide problem of marine litter. Although MOOCs are a relatively recent educational phenomenon [39], most of the participants in this course had previously participated in at least one MOOC. Most students aimed at finding partners to strengthen their individual capability. Hence, most participants reported that their main goal was to explore the possibilities of working with other organizations on the problem of marine litter, and to explore the possibilities of working with other people on the problem of marine litter. The results presented in this study show that besides being a channel for knowledge building MOOCs are convenient environments to scaffold networks around an environmental problem. Participants in the course were able to connect and create action plans during the course, as well as use their own social networks to monitor the activity of relevant people and organizations.

Digital media are powerful educational artifacts offering opportunities to create knowledge, experience, and content. They have a common purpose by bringing together participants with similar interests and objectives, and are openly connected on platforms that facilitate teamwork [40]. In research question two, we aimed to explore the participants' perspective regarding the influence of digital media to promote real actions against marine litter, in contrast to alternative factors such as formal education or the education given by parents at home. The results presented in this study show that the participants in the MOOC believe social networks are the digital media with the higher potential to foster real actions to combat the problem of marine litter (Table 4). Research shows that social media has become the primary news source for most people. Additionally, social networks facilitate participants to remain connected when the course ends and facilitate long-term actions that might better fit their availability based on time and location. Participants in the MOOC used the platform's forum to ask about technical problems or perform tasks requested in order to obtain the certificate. However, the interactions reported by students in social networks were more critical and reflective. The fact that users were more familiar with tools such as Facebook or Twitter facilitated the elaboration of opinions with richer multimedia content, for example, a student used videos to denounce a toxic spill. Other participants shared photos and comments about their holidays while using their reusable metallic water bottle.

Taking an educational perspective, the results presented in this study show participants recognized "family education" and "formal education" as the most relevant tools to promote actions. Education seems to be the key tool for promoting actions aimed to combat marine litter, and consequently any problem that requires a worldwide environmental change [29].

Research question three was aimed at exploring the potential of MOOCs to foster environmental activism combating the worldwide problem of marine litter. The results obtained in the pre- and post-questionnaire suggested that students had the perception of being (slightly) more active combating the problem of marine litter as a consequence of participating in the MOOC. The analysis of the results in the Wilcoxon test confirmed this assumption. However, these conclusions should be interpreted cautiously based on the high difference of participation between the pre- and the post-questionnaire. Participants reported that the MOOC helped them to (1) digitally connect people involved in combating garbage, (2) spread enthusiasm, (3) develop a collective intelligence, (4) disseminate the participation in existing real actions, and (5) start actions at the individual level.

The rise of digital video worldwide may be one of the causes of the exponential growth of MOOCs [41]. The evaluations of MOOCs and their latest technological advances suggest a greater interaction and collaboration using multimedia [24]. The MOOC on Marine Litter comprises different digital instruments such as videos, interactive maps, social networks, group tasks, and discussion forums. In research question four, we aimed to explore which of these instruments have more potential to promote actions to combat the problem of marine litter in the world. Students participating in this study reported that the videos included in the MOOC were the digital instrument with a higher potential to instigate individuals to perform an action. These videos described the problem of marine litter, identified the main sources of waste, and exposed real cases where solutions were being implemented at the local level. The second best valued digital tool was the world map of projects of the Marine Litter Network (Figure 3). This map allows participants to locate nearby projects, publicize their actions, and contact to actively contribute to them. The projects are classified by category (action plans, awareness raising, cleaning of spaces, education, emergency response, monitoring, prevention and research) and any person can request the inclusion of a new project.

Students participating in the course initiated individual actions to combat the problem of marine litter such as training divers to collect garbage, installing trash cans on beaches and making signs to raise awareness, participating in the cleanups of beaches (rivers and natural spaces), contributing to chats and campaigns for awareness in educational centers, raising awareness among family and friends about marine debris, and stopping the use of single-use plastic bottles.

Likewise, students worked individually to analyze case studies, but they also worked in groups to design action plans to initiate actions at their local environments to solve the global problem of marine litter in the world. Research question five was aimed at exploring the specific actions of environmental transformation that can be created and disseminated in a MOOC. Section 3.3 describes some of the most relevant examples which include: awareness programs for students and teachers of municipalities, initiatives aimed at minimizing the use of plastic bags, programs for recycling fishing nets thrown into the sea, school programs scheduling one day a week without plastic and collecting waste, wastewater treatment plans in port stations, awareness campaigns for music festivals, plans for the introduction of compulsory subjects in early childhood education, and plans to promote regulatory change on the use of municipal beaches.

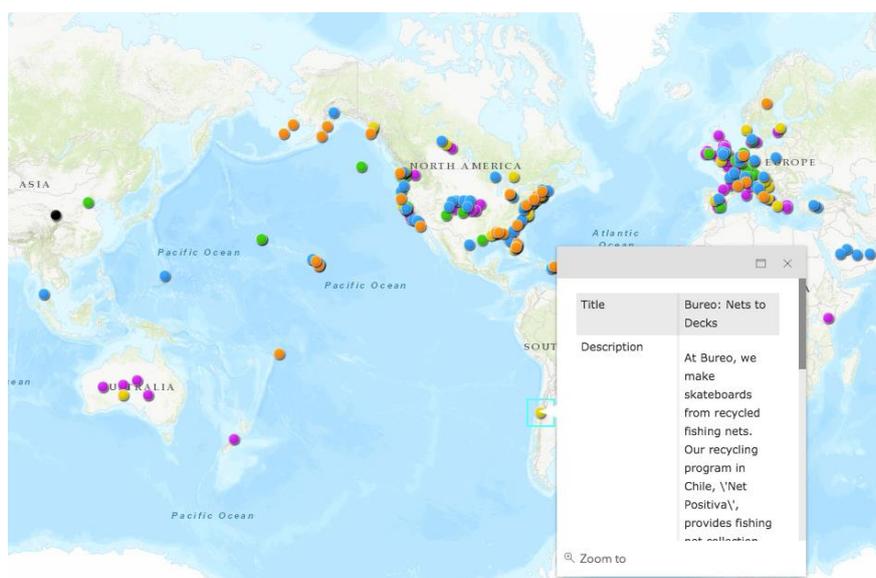


Figure 3. Active groups within the global partnership on marine litter.

5. Conclusions

Overall MOOCs are suitable tools to advocate and instruct new ways to promote environmental actions against a worldwide problem such as the marine litter. MOOCs provide a sustainable approach to spread accessible and cost-free learning content to the whole world. Participants in MOOCs are commonly digitally competent as they can explore web pages, spot learning opportunities, watch videos, complete assessments, participate in forums, connect with colleagues in social networks, edit contents, investigate case studies, and design action plans. However, are participants technically qualified to put action plans into actions to combat marine litter? Providing in-depth knowledge is the key to identifying the origin of the problem and to providing reachable solutions.

Moreover, this paper shows that students enrolled in the course aimed at identifying people and specialized organizations to join skills, knowledge, and experiences towards joining forces to combat a worldwide problem (see Section 3.1.2).

From a critical perspective, environmental activists might sometimes be isolated in the virtual world leading to inconclusive actions. Therefore, it is key to facilitate ways to enroll and to participate in active groups to keep the germ of environmental activism from the virtual world (see Section 3.2.1, perceived activism) and also alive in the physical world. MOOCs should be ideally combined with social networks to enable the communication between actors beyond the walls of the platform, but also beyond the duration of the course. Challenges in social networks might be convenient tools to spread specific actions of environmental transformation, for example, “day without plastic challenge”, “home without one-use plastic challenge”, and “non-plastic music festival challenge” (see Sections 3.2.4–3.2.6 and 3.3).

Further research should explore how educational interventions, like MOOCs, might provide guidance on how to prolong sporadic environmental actions into personal long-term habits. Longitudinal studies might help to shed light on this issue.

Limitations

The following factors limited the conducted research:

1. Questionnaires were anonymized. Therefore, it was not possible to correlate the answers between pre- and post-questionnaire, the case studies, and the action plans.
2. This work describes the activity of 3632 participants taking an active role and defining applied action plans in their local area. However, this study did not investigate the barriers that participants might have found to put their action plans into practice. Further explanation on these factors would help to understand how to address the problem of marine litter by individuals.
3. Differences between the number of participants in the MOOC (n = 3632) in the pre-questionnaire (n = 1098) and the post-questionnaire (n = 121). As the participation in the questionnaires was optional, there was a decreasing number of students in the tests, and consequently, the conclusions described in this paper must be considered cautiously.
4. Some of the conclusions raised in this study (see Sections 3.2.1 and 3.2.2) should be taken cautiously as they are positioned from participants' self-reports on environmental activism.

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