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Impact of an intervention for reducing waste through educational strategy: A Mexican case study, what works, and why?

P. Torres-Pereda [a], E. Parra-Tapia [b,*], M.A. Rodríguez [c], E. Félix-Arellano [d], H. Riojas-Rodríguez [d]

[a] Center for Health Systems Research, National Institute of Public Health, Av. Universidad 655, CP 62100 Cuernavaca, Morelos, Mexico
[b] Health Jurisdiction No. 02 North, Ministry of Health, Francisco I. Madero 125, CP 40000 Iguala de la Independencia, Guerrero, Mexico
[c] Independent Reseacher, Mexico City, Mexico
[d] Environmental Health Department, Center for Population Health Research, National Institute of Public Health, Av. Universidad 655, CP 62100 Cuernavaca, Morelos, Mexico

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ABSTRACT

Generation and inadequate management of solid waste constitute a global challenge. Projections for 2050 portend an annual increase of 3.40 billion tons of waste. This study assessed the impact of an environmental education intervention (EEI) aimed at reducing waste generation and fomenting pro-environmental behaviors in an academic public-health institution in Mexico. The EEI was implemented over 20 months using a model of behavior change. Using a mixed-method design (QUAN + qual), baseline and follow-up measurements were performed through electronic questionnaires (n = 754), focus groups (n = 20), and waste quantification. A double-difference model was performed to measure pro-environmental behaviors impact: overall and by sex, age, educational level and function within the institution. Waste quantification was performed using a quartering method and weekly monitoring. The qualitative data were studied through thematic analysis. As a result of the EEI, women reduced their use of multilayer packaging (−15.6 pp, $p < 0.05$) and frequent use of non-ecological materials (−17.6 pp, $p < 0.05$). Graduate-level participants reduced their regular and frequent use of these materials (−33.3 pp, $p < 0.05$, 27.6 pp, $p < 0.01$), while those with lower educational levels increased their ecological behavior at home (12.1 pp, $p < 0.05$). Waste generation dropped by 60.1% vis-a-vis the baseline measurement. Our qualitative findings showed a relationship between holding a position of power in the institution and recycling. They also revealed that available infrastructure for separating waste contributed substantially to the observed impact. With actions centered on physical structure, community practice and institutional policy components, the EEI improved the pro-environmental behaviors and perceptions of participants.

1. Introduction

The generation and inadequate management of solid waste have become one of the most urgent challenges in the environmental arena (Adeniran et al., 2017; Ojedokun, 2011). Apart from constituting a major source of pollution (Rodríguez et al., 2015; SEMARNAT, 2016), solid waste contributes to the depletion of natural resources and has adverse effects on human health (Tello et al., 2011; Adogu et al., 2015; Kiran et al., 2015; Giusti, 2009).

Global estimates have placed annual waste generation at 2.01 billion tons (t) averaging 0.74 kg/inhab/day. Projections for 2050 portend a 70% annual increase in waste generation, pushing the annual figure up to 3.40 billion t (Kaza et al., 2018). The countries in the Latin America and the Caribbean region contribute 11% of global waste, that is, 2.31 million t, annually, averaging 0.99 kg/inhab/day (Kaza et al., 2018).

Mexico is experiencing critical problems caused by urban solid waste (USW) generation (INEGI, 2011; SEMARNAT, 2016). Although integrated waste management is regulated by federal laws such as the General Law for the Prevention and Integrated Management of Waste (LGPGIR) (DOF, 2003), USW generation grew by 61.2%, or 53.1 million t, between 2003 and 2015 (SEMARNAT, 2016), bringing the national average to an above-regional level of 1.2 kg/inhab/day (SEMARNAT, 2016; Hoornweg and Bhada-Tata, 2012; Hernández-Berriel et al., 2017).

USW are those generated in institutions, homes, and public establishments, such as containers, packaging, organic and consumer products (DOF, 2003; SEMARNAT, 2016). In Mexico, UWS are represented by organic waste (52.4%), paper and cardboard

* Corresponding author.
E-mail address: elenaparrata@gmail.com (E. Parra-Tapia).

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(13.8%), other (12.1%), plastics (10.9%), glass (5.9%), and 4.8% by aluminum, textiles and metals (SEMARNAT, 2016).

UWS management consists on physical separation for reuse and recycling, biological treatment such as compost; and elimination of sanitary landfills and controlled sites (74.5%), uncontrolled areas (21%) and recycling (5%) (SEMARNAT, 2016).

The problems of waste management ensue primarily from anthropogenic activities. At the individual level, its mechanisms are linked to people's attitudes and behaviors (Erhabor and Don, 2016). The promotion of good management practices (Noguera-Oviedo and Olivero-Verbel, 2010; Ağdağ, 2009) must center on strategies for reducing, recycling and reusing waste materials (Del Cimmuto et al., 2014; Armijo de Vega et al., 2003).

Higher education institutions (HEIs) are microcosms marked by significant waste management challenges (Gallardo et al., 2016; Adeniran et al., 2017). As part of their institutional operation and responsibility, they need to adopt and promote environmental education strategies aimed at creating sustainable environments within and beyond their communities through university outreach programs (Armijo de Vega et al., 2003, 2008; Gallardo et al., 2016).

The literature on HEIs includes several studies of waste management systems (WMS) focused on recycling (Armijo de Vega et al., 2003, 2008; Kelly et al., 2006; Espinosa et al., 2008; Smyth et al., 2010; Disterheft et al., 2012; Geng et al., 2013; Ebrahimi and North, 2017). Other reported experiences refer to environmental diagnoses (Smyth et al., 2010; Saleem et al., 2019; Tiew et al., 2019b), baseline data reports to create WMS (Kelly et al., 2006; Zhang et al., 2011; Tiew et al., 2019a), design of proposals to implement WMS (Geng et al., 2013; Makrakis and Kostoulas-Makrakis, 2016) or the results of recycling actions in waste reduction (Largo-Wight et al., 2013; Ebrahimi and North, 2017).

In HEIs, the design of interventions aimed at recycling usually includes the implementation of infrastructure (Mason et al., 2003; Armijo de Vega et al., 2008; Smyth et al., 2010; Ebrahimi and North, 2017), the additional use of visual communication strategies (Largo-Wight et al., 2013; Tiew et al., 2019a), and other interventions address educational components for pro-environmental behavior change (Makrakis and Kostoulas-Makrakis, 2016; Tangwanichagapong et al., 2017.

The literature evidences the need for further research on the subject. Most of these studies have installed bin systems and their results show an increase in recycling (Kelly et al., 2006; Smyth et al., 2010; Zhang et al., 2011; Largo-Wight et al., 2013; Tiew et al., 2019a). Although these studies report a reduction on the amount of waste that is sent for treatment or disposal, they do not rigorously assess subjects' behaviors or seek to reduce the consumption.

Even though interventions have shown satisfactory results when modifying knowledge, attitudes and practices, they have been developed in clinical settings, are short-lived, their pre-post evaluations are only quantitative, and have not considered measurements for waste reduction (Tabash et al., 2016; El-Gilany et al., 2017). Other studies have shown a waste reduction, but the increase of self-reported behaviors is not observed (Tangwanichagapong et al., 2017).

The promotion of behavioral changes in waste management has been the object of several continuous education initiatives and environmental education strategies (Wismer and López de Alba, 2011; Armijo de Vega et al., 2003; Moore and Boldero, 2017; Tangwanichagapong et al., 2017). Evidence results indicate that lasting changes occur gradually (Ajaps and McLellan, 2015; De Young, 2011). Some authors point out that recycling consists of behaviors that vary in terms of adoption, maintenance, cost, and effort; therefore, it is important to have behavior change models to succeed (Moore and Boldero, 2017).

The role of environmental education for behavior change is of primary importance because it raises awareness of the problem (Erhabor and Don, 2016; Seng et al., 2018) and influences actions at the individual and community levels (Álvarez and Vega, 2009; Rodríguez et al., 2015) through the generation of knowledge, attitudes and behaviors in favor of caring for the environment (Pooley and O'Connor, 2000; Hansmann et al., 2005; Ajaps and McLellan, 2015; Ebrahimi and North, 2017).

While developed countries have reported positive results from their initiatives to reduce and recycle waste (Gallardo et al., 2016; Disterheft et al., 2012; Ebrahimi and North, 2017). Mexico has generated limited evidence on the impact of its efforts to improve waste management and the strategies it has adopted to advance environmental protection through HEIs (Armijo de Vega et al., 2008). With a focus on characterizing and quantifying waste generation (Maldonado, 2006; Armijo de Vega et al., 2008), most studies in Mexico have provided minimal information on the effects of HEI initiatives, they have not explored the social processes of change with qualitative methods nor have included an environmental education component based on a behavior change model (Armijo de Vega et al., 2003, 2008; Maldonado, 2006; Espinosa et al., 2008). It is thus necessary to rigorously evaluate the environmental protection interventions in Mexico in order to understand the impact of their actions and their action mechanisms, generate scientific evidence for decision-makers and guide the design of integrated management strategies that can respond to the urgent environmental health problem facing Mexico.

The National Institute of Public Health (INSP), a center for research and higher education in the field of public health, is a model institution in Mexico with great influence in Latin America. Its mission is to serve as a leader in innovation, multidisciplinary research and knowledge generation for the development and implementation of public policies in health. Given its prominent position in public health, an environmental management program was developed and conducted within the *INSP* framework. Using a mixed-method approach, we assessed the impact of an EEI aimed at reducing waste generation and fomenting pro-environmental behaviors among the Institute community members.

2. Material and methods

2.1. Study design

EEI impact was assessed using concurrent mixed methods, with the qualitative component integrated under the quantitative component (QUAN + qual) (Creswell et al., 2003; Bishop, and Holmes, 2013). The latter served to measure the effects of the intervention, while the qualitative information helped to understand the mechanisms underlying the effects and the way they were perceived by the population. Qualitative and quantitative data collection was undertaken separately; analysis was achieved through a comparison and contrast exercise in which the qualitative component helped to understand and explain the results of the quantitative component (Creswell et al., 2003; Creswell and Plano, 2007).

The EEI had a total duration of 20 months (January 2014–August 2015) and included baseline (September 2013) and follow-up (December 2015) measurements. The study comprised two *INSP* campuses located in two cities in central Mexico, with intervention activities implemented in only one. The populations at both sites were composed of researchers whose functions centered on teaching and the generation of scientific knowledge, administrative and maintenance staff and students enrolled in the *INSP* master's and doctoral programs.

"Intervention group" was the designation used for the population at the *INSP* campus where the EEI took place; the population

at the alternate *INSP* campus was designated as the "control group." Intervention campus was assigned arbitrarily, with no endogenous involvement. The availability of personnel was taken into consideration for the development of EEI activities.

2.2. The environmental education intervention (EEI)

The EEI was designed according to the principles of the PRECEDE–PROCEED model (Fig. 1), which has proven effective in healthy-behavior strategies at the population level (Glanz et al., 2002; Green and Kreuter, 2005). This model comprises nine phases, beginning with an exhaustive evaluation before planning the intervention (the PRECEDE principle) and concluding with an evaluation after completing the intervention (the PROCEED principle). The purpose of the latter was to measure the effectiveness of the initiative (Wright et al., 2006; Green and Kreuter, 2005). Our study covered the phases on the continuous line in Fig. 1, omitting Phases 7 and 9.

Phases 1 and 2. Focus groups (FGs) were used to identify the needs, as perceived by the *INSP* community. Environmental problems were determined through an integrated diagnosis regarding water, energy, USW and special handling waste (SHW).

Phase 3. An electronic questionnaire and FGs were used to analyze the baseline behaviors of the community with respect to USW and SHW management and to related environmental-protection practices in the *INSP* and at home.

Phase 4. Factors susceptible to change in behavior were determined and classified as predisposing, facilitating and reinforcing factors.

Phase 5. A diagnosis to was carried out to identify and assess any *INSP* requirements that were likely to obstruct or facilitate EEI development and implementation. The following aspects were addressed: budget, resources, organizational capacities and institutional compatibility.

Phase 6. Implementation of the EEI: Components, strategies and activities are described in Supplementary Material 1 and Supplementary Material 2 (EEI video).

Phase 8. The effects of the EEI were assessed according to four indicators: (1) reduced consumption of single-use disposable materials; (2) reduced USW generation; (3) improved SHW management; and (4) improved pro-environmental behaviors at home.

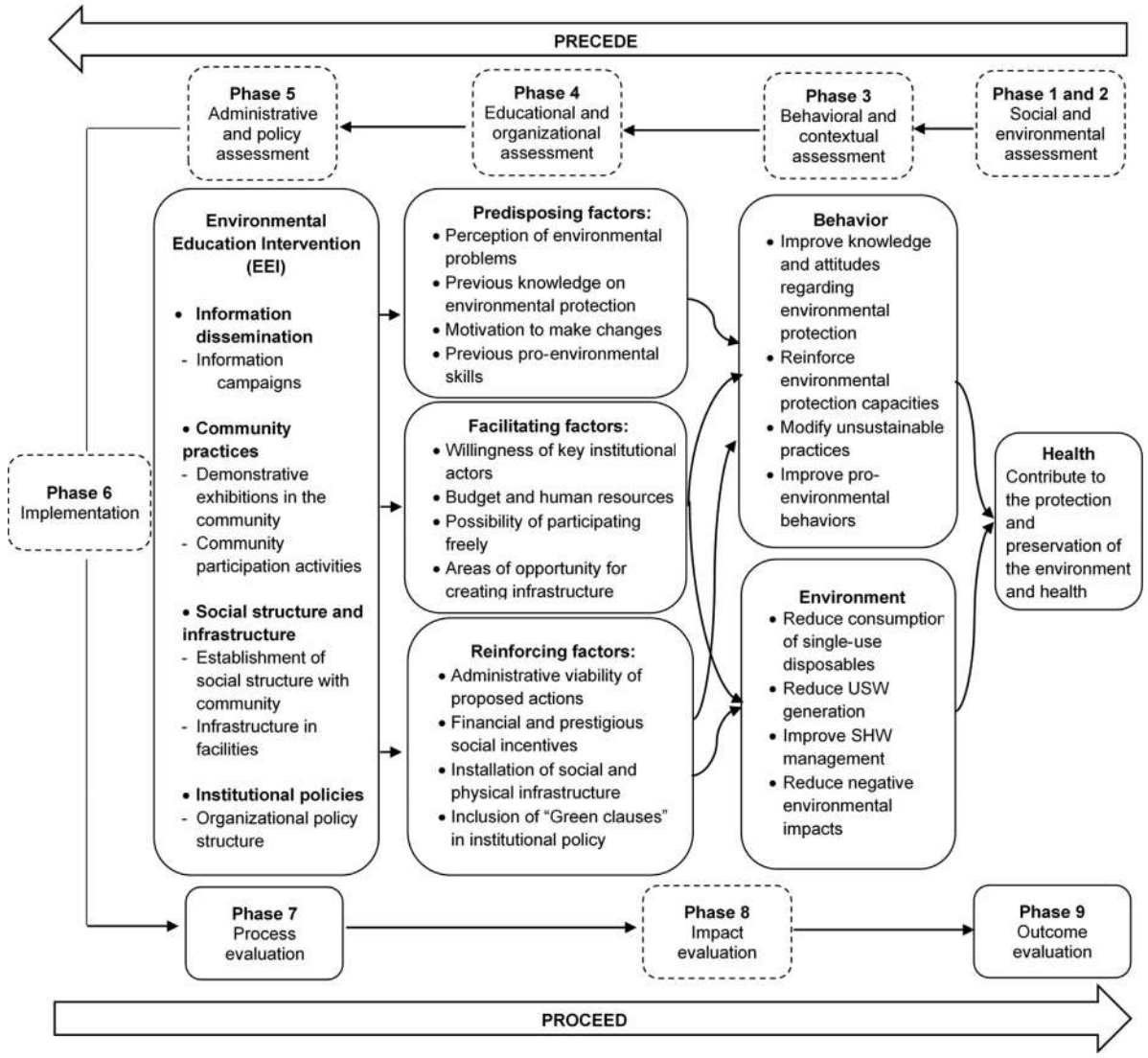

Fig. 1. EEI scheme adopted from the PRECEDE-PROCEED theoretical model.

2.3. Study population

2.3.1. Sample: quantitative component

The study universe included all the employees and students registered with the *INSP* (n = 1712). It was composed of 1268 individuals from the intervention group campus and 444 from the control group campus. Information on the configuration and size of the groups was obtained from official administrative sources. During the baseline and follow-up measurements, we gathered information on 881 and 936 participants, respectively. The response rates for the electronic self-administered questionnaire in the intervention group were 51% at baseline and 60% at follow-up; they were 52% and 41%, respectively, for the control group.

For our analysis, we included individuals who provided information at both measurements and excluded those with missing values. Our final sample was made up of 377 participants: 302 from the intervention group and 75 from the control group (Fig. 2). While excluding observations cut back our sample size considerably, it should be noted that no endogenous involvement occurred during the arbitrary assignment of group members. We selected the difference-in-differences (DD) model to analyze our sample by virtue of its capacity for controlling inter-group differences. The study sample was therefore adequate for our quantitative analysis. The strength of using a mixed-method design should also be noted.

2.3.2. Sample: qualitative component

To ensure representation of all the subgroups (both intervention and control), we selected the qualitative sample using the maximum variation purposive method (Teddlie and Yu, 2007) to generate information on the widest array of possible cases in order to establish comparisons among the different situations. We conducted a total of 20 FGs (9 at baseline and 11 at follow-up), with 109 participants, 54 at baseline and 55 at follow-up. Students were excluded from the FGs since they were a fluctuating population which at the time of the follow-up measurement had completed their school year. (Table 1), using field diaries for each FG as a data validation mechanism. Participants were recruited by means of an open invitation to the entire *INSP* community.

2.4. Instruments and variables

2.4.1. The quantitative component

For EEI indicators 1, 3 and 4, an electronic, self-administered questionnaire was distributed to every *INSP* community member and sent out periodic reminders to ensure its completion. The questionnaire remained available from three months before to three months after EEI implementation (See Supplementary Material 3: questionnaire).

The questionnaire was designed according to previously published instruments and a literature review of three thematic axes on the promotion of environmental protection (Sureda and Colom, 1989; Álvarez and Vega, 2009; Corral, 2010). Our study covered three of the six modules in the questionnaire: (1) sociodemographic characteristics; (2) behavior towards USW and SHW at the *INSP*; and (3) environmental protection practices at the *INSP* and at home (Sureda and Colom, 1989; Álvarez and Vega, 2009; Corral, 2010).

2.4.2. USW quantification and composition

For EEI indicator 2, USW generation and composition were quantified at the intervention campus. At baseline, the quartering method, a procedure established by Official Mexican Standard AA-015-1985 (DOF, 1985a) was followed. The volumetric weight of the USW was determined *in situ* (NMX- AA-019-1985) (DOF, 1985b). Then, it was separated and classified and the amounts of its subproducts was estimated (NMX-AA-022-1985) (DOF, 1985c). At follow-up, the subproducts were weekly monitored, assessing their types and weights. The data was registered on record sheets and electronic logs during the development of the EEI to determine the amount of waste generated at the campus.

2.4.3. The qualitative component

FGs and measurements were conducted in the intervention and control groups. To this end, open invitations were distributed to all research, administrative and maintenance staff. At the FGs, the perceptions and experiences of participants, in relation to EEI indicators 1, 2, 3 and 4, were explored. During discussions, four specific themes were addressed: (1) perceptions concerning the environment, natural resources and the environmental crisis;

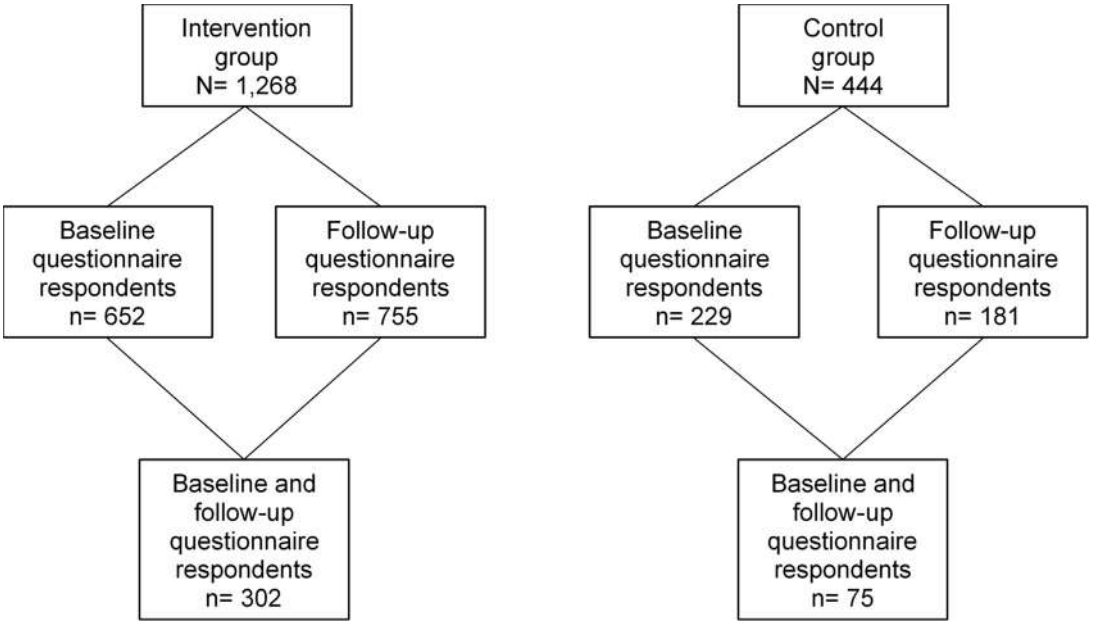

Fig. 2. Configuration of the study sample and groups.

Table 1
Qualitative sample: focus groups.

Measurement	Group	Researchers	Administrative and maintenance staff	Number of participants	Total*
Baseline	Intervention	3	2	31	5
	Control	2	2	23	4
Follow-up	Intervention	2	3	29	5
	Control	2	4	26	6
Total*		9	11	109	20

* Total: total number of focus groups by intervention group, control group and study population (research, administrative and maintenance staff).

(2) consumption and management of resources (USW, SHW, water and energy) at the *INSP*; (3) environmental behavior and willingness to change; and (4) environmental attitudes. Additionally, an EEI evaluation was included (5) during the follow-up measurement.

2.5. Data analysis

2.5.1. The quantitative component

EEI impact was assessed according to eight outcome variables. Four of them, indicated directly by the respondents on the questionnaire (dichotomous), concerned the types of materials used to introduce food into *INSP* facilities: 1. plastic wrapping, 2. disposable plastics (plates or cups), 3. Disposable expanded polystyrene, commonly known as Styrofoam (plates or cups) and 4. multilayer packaging.

The remaining four variables were also constructed according to the reports of respondents: 1. use of non-ecological materials: plastic wrapping, plastic and/or expanded polystyrene disposables and/or multilayer packaging; 2. frequent use of non-ecological materials: daily or four days a week; 3. Improper disposal of SHW: depositing one or more of the following SHW materials in trash containers at the *INSP* or at home: cell phone batteries, alkaline batteries, printer ink cartridges, mercury flashlights, electronics and/or insecticide packages; and 4. pro-environmental behavior at home: performance of one or more of the following practices at home: separation of organic/inorganic waste composting of kitchen waste and/or bringing their own bags when shopping.

The DD model controls for differences among study groups when the differences are fixed over time (Khandker et al., 2009). Hence, for those characteristics that remained unchanged in our study (regardless of whether they were observable), this model yielded unbiased estimates of the EEI impact.

The following statistical model was used:

$$y_{it} = \alpha + \beta_1 \cdot t + \beta_2 \cdot T_{it} + \vartheta_i + \varepsilon_{it} \quad (1)$$

where:

y_{it} represented the value of the outcome variable and $i - th$ the individual in period t;
T_{it}. represented the intervention variable, with 1 indicating whether the $i - th$ individual in period t received the intervention and 0, otherwise;
t represented the period variable, with 0 referring to the baseline measurement (2013) and 1 to the follow-up measurement (2015);
β_1 stood for the change observed over time (before-after comparison) in the absence of intervention (control group);
β_2 captured the impact of the intervention;
ϑ_i referred to the vector for fixed factors: variables that remained constant over time (sex, educational level, function within the *INSP*, etc.); and,
ε_{it} $N(0, \sigma_\varepsilon)$ denoted the error term.

EEI impact was estimated both globally and by sex (female and male), age group (20–39 and 40–63 years), function within the *INSP* (administrative, research or student), and educational level: high school or less, bachelor's degree, or master's/doctorate degree.

For the age groups, the sample size was adopted as the criterion and established two quantiles in order to maximize the minimum number of observations in each category.

The level of statistical significance was 90% ($p\text{-value} \leq 0.10$). The estimator used is commonly known as a "*within estimator*" or "*fixed effects estimator*." We estimated robust errors to control for heterocedasticity and intra-cluster correlation, as repeating observations would have violated the assumption of independent errors. For statistical analysis, Stata (version 14.2) software was used.

2.5.2. The qualitative component

A thematic analysis (Fereday and Muir-Cochrane, 2006) was conducted for the qualitative component, creating analytical categories to assist in finding themes that would allow for understanding the phenomenon being analyzed and provide a detailed and articulate explanation of the study questions.

For the qualitative data, we created 11 analytical codes were created for the five themes explored in the FGs. In turn, the analytical codes were broken down into 27 sub-codes. During the EEI, only those codes related to themes 2 and 5 of the qualitative assessment were analyzed. Data were analyzed comparing the group of researchers to the group of administrative and maintenance staff, given their different functions in the institution: the researchers played an active role in the definition of institutional standards while the administrative staff provided support. Additionally, the group of researchers consistently held master's and doctorate degrees while the other group members had attained bachelor's degrees or less.

The information gathered at the FGs was audio recorded with prior informed consent from participants and transcribed verbatim. Two rounds of readings and the data were carried out analyzed independently by two researchers to ensure interpretative triangulation. Data were analyzed using Atlas.ti (version 7.5.7) software.

2.5.3. Method integration

EEI impact was assessed under a mixed-method approach using a complementarity strategy to integrate the results (Creswell, 2015). This allowed for a comparison and contrast exercise, where the quantitative data helped to understand the magnitude of EEI effects, and the qualitative information, to explain, analyze in greater depth and understand the perceived effects of the EEI from the viewpoint of the participants, thus complementing our quantitative findings. The results were analyzed for each of the quantitative outcome variables and these were compared and contrasted with the qualitative findings for the same topic.

2.6. Ethical aspects

Our study was approved by the *INSP* Research Ethics Committee. FG participants joined the study voluntarily after providing oral consent. It was clearly explained to them that their participation would be handled in a confidential and anonymous manner

through the allocation of codes to their commentaries and responses on the questionnaire.

3. Results

3.1. Quantitative: characteristics of the population

Both the intervention and control groups contained greater proportions of women than men (70% and 59%, respectively); statistically significant differences were observed between the two ($p < 0.063$). Furthermore, over half of the intervention group members were 20–39 years old, whereas in the control group, ~60% were 40–63 years old ($p < 0.071$). The groups were comparable in the other characteristics listed in Table 2.

3.1.1. Impact of the EEI: globally and within population groups (EEI indicators 1, 3 and 4)

As shown in Table 3, the EEI reduced some non-ecological behaviors among participants. Globally, it achieved a drop of −14.98 pp ($p < 0.10$) in the prevalence of non-ecological materials used to bring food to the institution.

In stratifying the impact by sex, it was observed that women improved their ecological behavior at home (5.61 pp; $p < 0.10$) and reduced their use of frequently used non-ecological materials (−17.58 pp; $p < 0.05$), multilayer packaging (−15.57 pp; $p < 0.05$) and disposable plastics (−11.68 pp; $p < 0.10$). On the other hand, men showed tendencies the opposite of what was expected for most variables, although these results were not statistically significant. Nonetheless, even in this group, a significant reduction in the use of plastic wrapping was observed (−26.94 pp; $p < 0.10$).

By age group, a significant reduction in the use of expanded polystyrene disposables (−10.58 pp; $p < 0.10$) was observed among participants from 30 to 63 years old.

Concerning educational level for participants with master's or doctorate degrees, reductions were found in the use of non-ecological materials (−33.26 pp; $p < 0.05$), in the frequent users of these materials (−27.60 pp, $p < 0.01$) and in the use of multilayer packaging (−13.99 pp; $p < 0.10$). Among those with a high school education or less, a reduction in the use of plastic wrapping (−28.79 pp; $p < 0.10$) and an increase in ecological behavior at home (12.12 pp; $p < 0.05$) were noted.

As regards the impact of the EEI by function within the *INSP*, researchers significantly reduced their use of non-ecological materials (−22.70 pp; $p < 0.05$), while administrative staff demonstrated a significant decrease in the use of disposable plastics (−16.42 pp; $p < 0.10$) as well as a significant increase in ecological behavior at home (9.04 pp; $p < 0.10$). No statistically significant results were found regarding the improper disposal of SHW among any of the groups studied

Table 2
Characteristics of the study groups at baseline.

Characteristics	Control group n (%)	Intervention group n (%)	p-val[a].
Sex			
Female	44(58.7)	211(69.9)	0.063*
Male	31(41.3)	91(30.1)	
Age groups			
20–39 years	32(42.7)	164(54.3)	0.071*
40–63 years	43(57.3)	138(45.7)	
Educational level			
High school or less	14(18.7)	40(13.3)	0.313
Bachelor's	25(33.3)	125(41.5)	
Master's or doctorate	36(48.0)	136(45.2)	
Function within the *INSP*			
Administrative	26(35.6)	128(42.7)	0.306
Researcher	27(37.0)	113(37.7)	
Student	20(27.4)	59(19.7)	

The N total per characteristic may vary as a result of missing data.
[a] P-value of the test (χ^2): Pearson's correlation ($Pr[\chi^2 \geq y|x]$).
* (p-val < 0.10).

3.2. Generation of USW (EEI indicator 2)

The diagnosis performed during the baseline measurement indicated that the intervention campus generated 31 t of waste annually, of which 82.1% (26.1 t) corresponded to waste recoverable through recycling while 17.9% (5.7 t) was trash. In comparing the baseline quantification with respect to monitoring and follow-up, a reduction of 15.7 t in recoverable waste and 3.4 t in trash were observed; this represented a 60.1% (19.1 t) reduction in the total waste generation reported at baseline. The recoverable waste categories showing the greatest reduction between the two measurements were hand towels, with 7.2 t, and plastics, with 4.3 t, in the form of polyethylene terephthalate (PET) packaging, high density polyethylene (HDPE) and polypropylene (PP). Glass (0.4 t) and multilayer packaging (0.8 t) showed the least reduction (0.4 t) (Fig. 3).

3.3. Qualitative results: focus group participants

The majority of FG participants were women; 71% and 62% of participants pertained to the intervention group at baseline and follow-up, respectively, while 52% and 81% pertained to the control group at baseline and follow-up, respectively. The average ages of participants were 48 years at baseline and 45 years at follow-up in the intervention group, and 45 years at baseline and 39 years at follow-up in the control group.

Qualitative findings revealed noteworthy results for the *INSP* workers (research and administrative staff) in the intervention and control groups, at both measurements. The most representative testimonies (Ts) illustrating these findings are presented in Table 4.

3.3.1. Perceptions at baseline: indicators 1, 2 and 4

(a) Perception of the need for and lack of structure for the proper management of USW

A key result for participants, but particularly for the group of researchers –and this without difference by type of campus– was an understanding of the need to protect the environment, with trash generation being recognized as problematic (Table 4, T1-T2). The researchers, in particular, recognized that an inadequate institutional infrastructure prevented waste separation, constituting a barrier to protecting the environment (T3).

(b) Capacity to act vis-a-vis USW management differentiated within the institution

Discussions revealed the different capacities of participants to act related to their functions within the institution. Research staff positioned themselves as change agents, representing examples for the rest of the community to follow in the face of the need to protect the environment (T4). Administrative staff conditioned their participation in the EEI on receiving authorization from their superiors (T5), affirming that the latter were examples to follow (T6) and expressing the need for training and motivation to separate waste (T7).

(c) Pro-environmental behavior at home differentiated by group

Table 3
Impact of the EEI globally and within population groups.

Outcome variables	Global	Sex		Age groups		Educational level			Function within the *INSP*		
		Female	Male	20–39 years	40–63 years	High school or less	Bachelor's	Master's or doctorate	Admin.	Res.	Stud.
Plastic wrapping	−10.83	−1.11	−26.94*	−12.75	−10.43	−28.79*	12.60	−21.53	−12,16	−12.22	−11.84
Plastic disposables	−5.39	−11.68*	3.81	0.51	−9.82	−13.64	−4.81	−6.44	−16.42*	0.79	4.82
Expanded polystyrene disposables	−0.29	−6.90	8.69	10.77	−10.58*	−8.33	9.09	1.89	1.38	−4.76	2.63
Multilayer packaging	−5.36	−15.57**	6.44	−7.25	−4.13	2.27	11.30	−13.99*	0.88	−5.87	−16.67
Non-ecological materials	−14.98*	−17.66	−12.00	−14.82	−16.47	−22.73	16.69	−33.26**	−17.29	−17.22	−13.70
Non-ecological materials (frequent use)	−6.21	−17.58**	7.12	−4.99	−6.60	14.39	16.49	−27.60***	−1.25	−22.70**	15.79
Improper disposal of SHW	2.18	−5.03	9.20	−0.08	4.46	17.19	12.22	−13.51	12.86	−8.11	11.76
Ecological behavior at home	0.22	5.61*	−7.14	−3.29	3.01	12.12**	1.15	1.57	9.04*	0.00	−9.48

Admin.: administrative staff; Res.: researchers; Stud.: students.
Level of significance: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

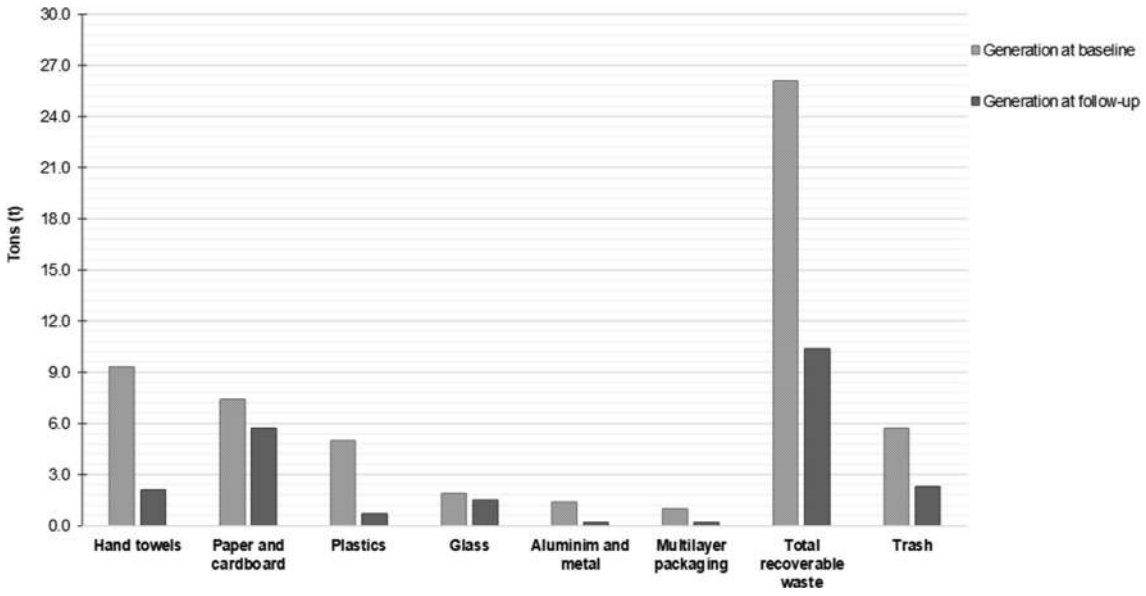

Fig. 3. Generation of recoverable and other waste at the intervention campus: results from quantification during baseline and follow-up measurements.

Researchers generally affirmed that they separated waste at home prior to EEI implementation (T8), while administrative staff made no such assertions in their discourses.

3.3.2. Perceptions at follow-up: Indicators 1, 2, 3 and 4

(a) Evaluation of the EEI: changes in institutional behavior and culture

The intervention group generally affirmed the adoption of relative changes within the *INSP* in the reduced use, separation and management of USW. These changes were perceived as the result of specific EEI actions by means of which staff was incentivized to embrace a reduction in the consumption of disposable materials, energy and USW (T9, T10).

In their discourses, participants recounted the components and activities of the EEI, highlighting those that allowed them to visualize the magnitude of the problem at the local level, and citing actions which they related to favorable changes in their environmental behavior. Among the actions most frequently mentioned as being relevant were the discount offered to cafeteria users who brought their own cups, as well as demonstrative exhibitions on the waste generated each week by the Institute. In addition, participants described what they called the creation of an "institutional culture" for protecting the environment (T10).

(b) Reduction in the use of disposables

Administrative staff emphatically affirmed the change observed in the utilization of single-use disposables which had been part of their daily consumption prior to the EEI; in their discourses they affirmed that this change of behavior was specifically related to EEI activities (T11), and the awareness generated by the EEI concerning the use of expanded polystyrene (T12).

(c) Structure, reduction of USW and challenges in the use of bins and sustainability

Participants affirmed that the installation of bins, the separation and classification of USW as well as the creation of storage space for recyclable waste were key in explaining the reduction in USW (T13).

In spite of this, they pointed to challenges in the use of the bins. They found that highly detailed classification (of paper and cardboard, glass, metal, plastics, organics and trash) generated confusion among users, some of whom –in the face of this

Table 4
Testimonies from the qualitative focus groups on the baseline and follow-up measurements.

	BASELINE: EEI Indicators 1, 2, and 4 **3.3.1 Perceptions of generation and proper management of USW at the *INSP* and pro-environmental behavior at home.**
	Barriers for proper management of USW
(T1)	R7: [. . .] *I believe that yes, [. . .] there is no doubt that the Institute should be an example in health, in environmental health. Look, the Institute has had success stories of, let's say, [. . .]in the case of tobacco, but in the case of environmental health [. . .] I think that [. . .] there are things that the Institute should certainly do. (FG_Control_Research_2013).*
(T2)	R1: [. . .] *I guess we produce a lot of garbage, a lot of pollution specifically garbage. [. . .] for example students have to deliver many things on paper* [. . .] *(FG_Control_Research_2013).*
(T3)	R6:*I think so, at the level of the institution. . .* R7: *Aha, aha. Then we could, we could separate the garbage, but as they say, we would need to make someone take it separately, wouldn't we? because if they are going to collect it together [mixed] then it doesn't make sense anymore, right? (FG_Control_Research_2013)*
	Capacity to act vis a vis USW within the institution
(T4)	R3: *I think that, like at home, here the example is given by the elders, and the elders start with our directors, etc. So, if you want a worker to make a change of attitude, how are you going to demand it, if you're not doing it? I believe that the example should also come from us [researchers] [. . .] and that it should permeate [. . .] if there is no willingness and empowerment, it doesn't work, it just doesn't work. (FG_Intervention_Research_ 2013)*
(T5)	R1: *And are we going to be given permission* [to participate in the EEI]*?* R2: *Because, it's complicated for us to be able to attend the courses and, all of that, it's complicated for [our bosses] to give us permission.* R3: *It would be worthwhile to be emphatic, that is, for the director to be emphatic in saying that our participation [in the EEI] is important. (FG_Intervention_Administrative _2013)*
(T6)	R4: *My boss is very careful and he has never made photocopies. For example, in a class for his students, the readings are sent to them electronically and I have seen him [. . .] but if he didn't do it I would follow his example. (FG_ Intervention_Administrative_2013)*
(T7)	R2: *I brought a little glass* [plastic], *and I saw inorganic-inorganic, two bins . . . I brought it here* [to the office] *and threw it in my bin* [without separation] . . . R3: *I mean, that's really what it is sometimes. At the moment you forget, which is organic and which is inorganic. (FG_Control _Administrative_2013)*
	Pro-environmental behavior at home
(T8)	R1: *From home I do actions, this is a facilitator to act at the political level* [in the public sphere]. *(FG_Intervention_Research_2013).*
	FOLLOW-UP: Indicators 1, 2, 3 and 4 **3.3.2 Perceptions of generation and proper management of USW and SHW within the *INSP* and pro-environmental behavior at home**
	Changes in institutional behavior and culture
(T9)	R12: *Of course! There has been a positive development since the "eco-INSP"* [EEI] *program began. It is positive because [. . .] because we have been shown the results and because I believe that not a few* [many] *of us who have participated have changed some of our habits that go against the environment. (FGs_Intervention_Research_2015)*
(T10)	R1: *I [. . .] saw an infographic published here on the intranet, where we are invited to save water, to separate solid waste [. . .].* R2: *Bringing your cup to the cafeteria* [avoid using disposable cups] *became a habit.* R1: *In the cafeteria. They put water fountains to decrease the use of PET,* [the EEI] *rewards you according to what you've done with a tree [. . .]* R3: *They have also done like an organic products fair* [. . .] R4: *Yes, I like the campaign they have done because, even at Christmas, they made a Christmas tree, right? which was very ecological [. . .]. They also made a huge, impressive expanded polystyrene sculpture. We realized how much* [expanded polystyrene] *is generated in a week. (FG_Administrative_Intervention_2015)*
	Reduction in the use of disposables
(T11)	R1: *Personally, I became aware, "say not to expanded polystyrene", I already made the decision, I don't buy it, I don't consume it, [. . .].* R2: *The light, if I'm going to leave my office for lunch, I really do turn off the printer, the light, the computer.* R3: *They eradicated a lot of the disposable.* R4: *The disposables, that is, in our area meetings, the change is already generated, for example, everyone bought his/her plate and his/her glass.* R3: *But, I think it* [EEI] *has accomplished a lot, we all agree that* [the EEI] *has made us aware, [. . .] we also take it* [practices] *to home [. . .]. In my work, we receive foreign and national visitors, for me it is always very cool to take them to [. . .].* R4: *The waste warehouse. . .* R3: *The warehouse [. . .]. It's kind of funny because the waste is there, but it's hygienic, [. . .] I take advantage of it and presume it [. . .] and people are shocked,* R4: *[. . .] we take our cup* [to the cafeteria] *and they charge us one peso less. . .* R5: *That's five pesos a week we've saved and I wonder why I'm going to be spending it on garbage, right? (FG_ Intervention_Administrative_2015)*
(T12)	R2: *I remember it worked, one day they put a big expanded polystyrene sculpture, which did impact me. I thought, this is what the institution accumulated in a week of expanded polystyrene. . .* R4: *Now, imagine. . .* R3: *Yearly! (FG_Intervention _Research_2015)*
	Management of the USW and challenges in the use of bins and sustainability
(T13)	R2: *Well, I think, apart from the workshops, the fact that you see the garbage bins opens the possibility to separate the waste, because they're there and they remind you every day, and when you're going to throw something away you have to separate it, depending on its usefulness.* R3: *And to be able to bring the trash, well, the waste from your house and see that you're not the only person doing it. You arrive at the waste warehouse and you see everything properly ordered, separated. [. . .] in the Institute you can go and take your USW* (laughs) *and here we go the mothers who have several children, "let's go to the institute to leave the trash [. . .] (FG_Intervention_Research_2015)*
(T14)	R3: *The bins were placed to separate the garbage, but not everyone uses them.* R4: *I think the bins are kind of confusing for me. They're unclear, that is, they're not practical.* R5: *For example, recoverable, what is recoverable, I don't know.* Q: *But, don't bins have labels explaining what type of waste goes in?* A4: *Yes, just because sometimes you go in a hurry [. . .] because you have a meeting and you have to study the labels. So, I feel like it should be something more, something quick, something practical. (FG_Intervention_Research_2015)*
(T15)	R3: *I see a lot of participation when they have done the fair [. . .] a lot of people come and buy organic products, but [. . .] like that day we enjoy the event and then we forget the commitment.* R4:*It's a lifestyle, it's not just that day. (FG_ Intervention_Administrative_2015).*
	Pro-environmental behavior at home differentiated by group
(T16)	R6: *Well, having a space to bring everyone recycled items was a very good idea. I started at home, separating, but once I've done it, what now?* [There's no structure for separation at municipal level] R7: *If I take it out to the collection truck, they're going to mix it, [. . .] the organic was used for composting, but I didn't know what to do with the inorganic. When this opportunity was opened at the institute, I started to bring it. I encouraged myself again to separate. (FG_Intervention_Research_2015)*

Table 4 (*continued*)

FOLLOW-UP: Indicators 1, 2, 3 and 4	
3.3.2 Perceptions of generation and proper management of USW and SHW within the *INSP* and pro-environmental behavior at home	
(T17)	R4: *[. . .] In my case I can say that since I started and became involved [in the EEI], I learned things that I implemented in my personal life, in my home. (FG_ Intervention_Administrative_2015).*
	TSHW management
(T18)	R1: *The toner cartridges for example, I don't know where I have to take them, do I give them to the cleaning person? [. . .] I don't know where to dispose of these* [waste]. *(FG_Intervention _Administrative _2015)*
	Unintended positive externalities
(T19)	R18: *With the outsiders [street food vendors outside the institution], we go for the "chilaquiles" [food] with our tupperware. At first, they said ay, ah, you really don't want a disposable, do you? just like, oh, funny! [. . .]* R19: *Oh, that's good.* R18: *And they* [street vendors] *aren't bringing expanded polystyrene anymore. (FG_Intervention _Administrative _2015)*
3.3.3 Control group	
	Absence of the intervention
(T20)	R3: *Well, the [EEI] program, as such, is not implemented, we have not been given complete information on how the program is implemented.* R1: *Okay, well, that's very important. Here people have not benefited from the program.* R2: *No.* R2: *At* [another site] *I think there have been benefits. A lot about how you separate garbage. (FG_Control _Research_2015)*
(T21)	R3: *On the other hand, our offices do not have stipulated bins or paper, organic and inorganic. Sometimes you don't even have garbage bins. This somewhat limits the possibility for us to take action in terms of reducing pollution, or positive actions for the environment. (FG_Control_Administrative_2015)*
(T22)	R1: *Right now, we don't know whether to separate the garbage or not, because when it gets to the dump everything goes together.* R2: *The truth, sincerely, you say, what's the use of separating it? [. . .], if when it goes [. . .] where are they going to deposit all the trash? it turns out that everything is mixed.* R1: *You say "what happened", don't you? What good did it do? (FG_Control_Administrative_2015)*

confusion– opted not to classify waste and treated all of it as trash (T14). In addition, it was recognized that change requires sustained action in order to become a lifestyle (T15).

(d) Pro-environmental behavior at home differentiated by group

Follow-up measurements corroborated what had been found at baseline. Research staff carried out pro-environmental actions at home prior to the EEI, and following this intervention began to implement recycling within the *INSP* (T16). For their part, administrative staff affirmed that they took home the knowledge acquired through the EEI on the separation of waste as a new practice (T17).

(e) SHW management

During the follow-up measurement, participants did not recognize an EEI impact with respect to SHW management, but SHW was nonetheless mentioned in their discourses (T18).

(f) Unintended positive externalities

Administrative staff stated that, as a result of the rejection of the use of disposables by EEI participants, people who had not received the intervention, such as street food vendors in the vicinity of the *INSP*, had stopped using and selling expanded polystyrene in their businesses. (T19).

3.3.3. Control group

In the control group, both research and administrative staff stated that the absence of EEI actions on their campus (T20) assured that no structure would be built for the separation of USW (T21) and affirmed that lacking an EEI as well as adequate infrastructure, no actions to protect the environment were taken (T20, T22).

3.4. Integrated results

The EEI had an impact on the reduction of the consumption of single-use disposables, presenting heterogeneous results by groups. Participants with a master's or doctoral level of education showed a significant reduction in the use of non-ecological materials (plastic packaging, disposable plastics and expanded polystyrene containers), while those with a high school education or less and working as administrative staff exhibited an increase in ecological behavior at home (Table 5).

For its part, the qualitative component allowed to better understand the relationship between pro-environmental behavior and the ability of actors within the social structure of the *INSP* to take action. On the one hand, researchers, generally possessing a master's or a doctorate degree, demonstrated a high capacity to act, grounded in knowledge and prior practice concerning environmental protection. Administrative staff with a bachelor's degree or less took additional actions at home as a result of the intervention; nonetheless, at baseline, they reiterated the barriers to taking similar actions within the *INSP* environment (Table 5).

With respect to the reduction in the generation of USW, we quantified a significant decrease in waste between the baseline and follow-up measurements. This reduction was reflected in the discourses of FG participants, who acknowledged having changed their consumption patterns as a consequence of the different EEI components, and even recognized the creation of what they called an "institutional culture" of protecting the environment. The qualitative component also allowed us to explain why the installation of the physical structure for classification of waste and recycling, as well as the incorporation of "green clauses" in institutional policies were recognized by participants as key EEI actions (Table 5).

4. Discussion

Our study presents, for the first time in Mexico, to the best of our knowledge, the results of an EEI impact evaluation of a case of study, using a mixed-method approach within a HEI, and contributes evidence for decision making in the area of waste management.

4.1. Reduction in consumption of single-use disposable materials

Overall, the pro-environmental behavior of participants modestly reduced the consumption and generation of non-ecological

Table 5
Integrated results using mixed methods: EEI indicators, response variables of the qualitative component, themes analyzed in the qualitative component and mixed results in contrast.

	Quantitative Findings	Qualitative Findings
EEI indicator 1: Reduced consumption of single-use disposable materials		
Outcome variables: Plastic wrapping Disposable plastics Disposable expanded polystyrene Multilayer packaging Non-ecological materials Non-ecological materials (frequent use) **Qualitative assessment:** **Theme 2**. Consumption and management of USW, SHW, water and energy.	■ **Global**: the EEI reduced the prevalence of the use of non-ecological materials (−14.98 pp*). ■ **1.1** Plastic wrapping: men (−26.94 pp*), participants with high school education or less (−28.79 pp*). ■ **1.2** Disposable plastics: women (−11.68 pp*); administrative staff (−16.42 pp*). ■ **1.3** Disposable expanded polystyrene: participants between 40 and 63 years (−10.58 pp*). ■ **1.4** Multilayer packaging: women (−15.57 pp**), participants with a master's or a doctorate (−13.99 pp*). ■ **1.5** Non-ecological materials: participants with a master's or a doctorate (−33.26 pp**). ■ **1.6** Non-ecological materials (frequent use): women (−17.58 pp**), participants with a master's or a doctorate (−27.60 pp***), researchers (−22.70 pp**).	• Changes in institutional behavior and culture regarding environmental protection derived from EEI activities and general perceptions (T9, T10). • Reduction in plastic wrapping and plastic disposables expressed primarily by administrative staff with high school education or less (T11). • Reduction in the use of expanded polystyrene reported by administrative staff (T11). • Special emphasis on awareness raising as regards the reduction in the use of expanded polystyrene (T12).
EEI indicador 2: Reduced USW generation		
Quantification of USW: Recoverable waste generation: hand towels, paper and cardboard, plastics, glass, aluminum and metal and multilayer packaging. Trash generation. **Qualitative assessment:** **Theme 2**. Consumption and management of USW, SHW, water and energy.	■ **2.1** Reduction of 60.1% in total generation of waste reported at baseline. ■ **2.1.1** Reduction in recoverable waste (15.7 t): waste showing the greatest reduction between both measurements: hand towels (7.2 t) and plastics (4.3 t); waste showing the least reduction: glass (0.4 t) and multilayer packaging (0.8 t). ■ **2.2** Trash reduction (3.4 t) at follow-up vs. baseline.	Participants recognized the difference that providing bins for waste separation made in regard to recycling actions (T13); this notwithstanding, they spoke of EEI challenges concerning the use of the infrastructure (T14, T15).
EEI indicator 3: Improved SHW management		
Outcome variable: **3.1** Improper disposal of SHW: cell phone batteries, alkaline batteries, ink cartridges, mercury flashlights, electronics, insecticide packages **Qualitative assessment:** **Theme 2**. Consumption and management of USW, SHW, water and energy.	**3.1** Without significant impact on the improper disposal of SHW: greater reductions were observed among participants with a master's or a doctorate (−13.51 pp) and researchers (−8.11 pp).	• Despite showing no effect regarding SHW, references to this type of waste emerged in the discourses of participants during the follow-up measurement. Contrarily, they were missing at baseline (T18).
EEI indicator 4: Improved pro-environmental behavior at home		
Outcome variable: **4.1** Pro-environmental behavior at home: separation of organic/inorganic waste, composting of kitchen waste and/or bringing their own bags when shopping. **Qualitative assessment:** **Theme 3**. Environmental behavior and willingness to change.	• **4.1** Pro-environmental behavior at home: women (5.61 pp*), participants with high school education or less (12.12 pp**), administrative staff (9.04 pp*).	• Researchers stated that they had adopted pro-environmental behavior in their homes prior to the EEI, but began to adopt this behavior at the *INSP* following the EEI (T16). • Administrative staff stated that they had begun to separate waste at home as a new practice (T17).
Emerging qualitative findings		
Emerging themes:	Positive externalities: Administrative staff recognized positive externalities in the reduction of disposables used by street vendors. (T19).	

Quantitative results expressed in percentage points (pp); Statistical significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Qualitative results: Testimonies (Ts) in Table 4.

materials; however, our results suggest that the EEI exerted greater statistically significant effects among women and individuals with higher levels of education.

The effect on women and their greater level of participation has been noted by authors such as Vicente-Molina et al. (2013) and Makrakis and Kostoulas-Makrakis (2016), who observed that pro-environmental behavior tends to be linked to altruistic motivations, more prevalent among women than men. Adogu et al. (2015) mention that being a woman significantly influences environmental practices, particularly as regards the management of waste. In this regard, our findings are in agreement that the women in our study reduced their consumption of frequently used non-ecological materials, plastic disposables and multilayer packaging to a greater extent than did their male counterparts. Conversely, men increased the level of their non pro-environmental behavior, albeit not to a significant extent; this phenomenon should be the subject of future studies.

No correlation between the age of participants and the outcome variables was found. However, the qualitative data showed specific patterns of behavior related to educational level and the function of participants within the *INSP*. Our findings demonstrate that job role, related to educational level, and the ability to take action on the part of participants in an EEI may condition the results of such an intervention within HEIs.

Some authors suggest that people with higher levels of education possess greater knowledge on the impact of waste management (Hammed et al., 2018), participate more than other populations (Kelly et al., 2006; Bailey et al., 2015), and are more motivated to adopt environmentally responsible behavior (Kelly et al., 2006; Lozano, 2006; Olli et al., 2001; Vicente-Molina et al.,

2013). The differentiated patterns of action within the institution to protect the environment indicate that researchers embraced pro-environmental behavior at home and expressed a desire to implement this approach within the *INSP*; this perspective was not found among administrative staff. Nevertheless, follow-up measurements of both groups show that the former constituting a clear presence within the HEI, with the latter beginning to implement actions at home.

In this respect, Velázquez et al. (2005) and Zhang et al. (2011) point out that HEIs are usually characterized by bureaucratic organizational structures with inefficient management, where support from leadership and a clearly defined environmental policy are critical components for the success of environmental strategies. For their part, Armijo de Vega et al. (2003) stress that education and motivation must be directed at the whole of the institutional community. Our study shows that the example provided by HEI leaders, as well as the involvement of different actors within the community, contribute to positive EEI results.

4.2. Behavior change

In the context of HEIs, there are few interventions that, in their design, address a conceptual model of behavior change (Makrakis and Kostoulas-Makrakis, 2016; Tiew et al., 2019b). In our study, the use of the PRECEDE-PROCEDE model contributed to reducing the consumption of non-ecological materials in infrequent and frequent users. Some authors point out that this model is suitable for modifying pro-environmental behaviors (Grol and Wensing, 2004; Moore and Boldero, 2017).

In our results, demonstration activities focused on raising awareness allowed participants to grasp the dimensions of the environmental problem caused by waste. Along the same lines, it has been shown that information can help people become aware of the consequences of their own behavior (Godfrey and Scott, 2011). In this connection, Kiran et al. (2015) showed that around 90.8% of those interviewed felt that they played an important role in solid waste management. Moreover, they affirmed that if people became aware of the fact that they were responsible for the problem of waste, then they would also perceive that they could do something to resolve it. Similarly in our study, participants showed interest in waste management, indicating that the EEI components that had most helped them understand the scale of the problem within the *INSP*.

4.3. Reduction in the generation of USW and SHW

With respect to the quantification of waste, our results are in agreement with those reported in the literature on the high potential for recycling waste generated by the HEIs (Armijo de Vega et al., 2008; Disterheft et al., 2012; Adeniran et al., 2017; Gallardo et al., 2016), rendering educational institutions ideal sites for environmental education aimed at waste separation and recycling.

We measured a reduction of 60.1% in waste generation, similar to other reported findings in a Mexican campus (67%) (Maldonado, 2006) and Canadian campus in Northern British Columbia, Canada (70%) (Smyth et al., 2010) after the implementation of a waste management program. In addition, the design of our evaluation allowed for observing the alignment between the reduction (17.9%) in the waste generation observed in the follow-up phase and the estimated impact of the EEI on reducing the generation of non-ecological materials among the population receiving intervention (−14.98 pp, $p < 0.10$).

Using the quartering method carried out during the baseline measurement, it was determined that 82.1% pertained to recoverable waste, information similar to that observed by Adeniran et al. (2017), whose classification of waste on a Nigerian university campus reported a recycling potential of 75%. In disaggregating the waste generated at follow-up, we observed that generation of paper and cardboard represented 44.9% of the total, consistent with figures reported by Armijo de Vega et al. (2008) in an HEI in northern Mexico (33.02%). While SHW management was not modified by the intervention, an awareness of its existence –absent during the baseline measurement– was incorporated into the discourses of participants at follow-up.

Our study enabled us to assess the role of the physical and administrative structure in pro-environmental behavior. It has been argued that the rate of recycling could be increased by as much as 33.5% with waste separation at the point of generation if separation bins were provided (Ikhlayel et al., 2016; Hammed et al., 2018). Our findings support the conclusion that adequate infrastructure and green clauses are central to the success of a recycling system (Abarca et al., 2013; Zhang et al., 2016; Ebrahimi and North, 2017). However, it must be stress that these types of strategies for separation and recycling of waste must enjoy economic support to assure their successful implementation (Mbuligwe, 2002; Ebrahimi and North, 2017).

Finally, one of the strengths of the present study is its robust design. Although educational interventions in the environmental area have been previously conducted, only few have been rigorously evaluated and when they have been evaluated, it has been done with quantitative methods only (Largo-Wight et al., 2013). This study contributes to the knowledge of the effectiveness of interventions in the framework of HEI's (Largo-Wight et al., 2013) while our mixed methods design allowed the understanding of the social mechanisms that explain the findings (Mason et al., 2003; Bailey et al., 2015; Makrakis and Kostoulas-Makrakis, 2016), going beyond the quantitative approach present in the literature (Ajaps and McLellan, 2015) and showing concordance between the findings.

4.4. Limitations

Our study has some limitations. On the one hand, the sample size was considered to have a significance level of 90% ($p\text{-value} \leq 0.10$). On the other hand, its findings can be generalized to other similar institutions and could be used to design larger studies, but several disadvantages limit the generalization and extrapolation of our results to other populations or settings: Because participation in the study was voluntary, participants may have had a self-selection bias with respect to pro-environmental behavior coupled with low response rates; the latter is considered common among surveys conducted electronically, owing to the lack of an interviewer to assist the interviewee in completing the questionnaire (Vicente and Reis, 2010; Ajaps and McLellan, 2015).

Given the transitory nature of the student population in the study, whose tenure in the *INSP* depended on the length of their study program (two years), our analysis was unable to determine the degree of change in their behavior, with the majority of students leaving the institution before our follow-up assessment. Finally, the quantification and composition of USW (quartering method and monitoring) was not carried out on the control group campus, making it impossible to compare the generation and reduction of waste at the group level in the study.

Finally, even when the study had with a small study population, our sample was self-representative, with the results internally valid in ensuring comparability among groups. Furthermore, the methods used allowed us to measure the changes in behavior attributable to the intervention, understand the perceptions of different groups of participants, quantifying the reduction in waste generation.

5. Conclusions

An intervention based on the principles of environmental education and designed under the PRECEDE-PROCEDE model, such as that carried out in our study, can enhance the pro-environmental behavior and sharpen the perceptions of participants while reducing the consumption of non-organic materials and reducing the production of USW sent to a final disposal within the framework of a HEI, as well as the promotion of pro- environmental behaviors at home. The creation of physical and organizational structures is key to cutting down waste and to its appropriate management.

In this first impact mixed-methods evaluation, positive effects were observed in the area of pro-environmental behavior, these impacts could continue as long as the EEI continues and orientate the design, implementation and evaluation of other interventions with a solid method and a model of behavior change in high educational contexts in developing countries.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wasman.2020.06.027.

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