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# ENCOURAGING SUSTAINABLE CONSUMPTION PATTERNS THROUGH MATHEMATICS AND EXPERIMENTAL SCIENCE IN HIGHER EDUCATION

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## Abstract
The United Nations adopted the 2030 Agenda for sustainable development in January 2016 with the aim of improving and achieving what had previously not been possible with the Millennium Development Goals. The role of education and educators of all levels and disciplines is crucial in the quest to advance towards a more sustainable world. At university level, and within the framework of the European Higher Education Area, which proposes an opportunity for change, a sustainable curriculum is not restricted to the inclusion of environmental content in the syllabi of the different subjects taught. However, integrating sustainability into university curricula leads to global changes in the educational process. This change of paradigm, acquires special relevance in pre-service teacher training since those future teachers are the ones who will contribute to the formation of the future generation of citizens. This work presents a proposal for introducing sustainability into the University curriculum, through education for responsible consumption in the subjects of mathematics and experimental science of future Primary School teachers at *Universitat Internacional de Catalunya*. The students were asked to fill in a questionnaire about their consumption habits before and after the educational programme. Changes towards more sustainable attitudes were observed in their routines after the intervention. These results show that through a properly designed and implemented educative proposal, it is possible to introduce changes into the consumption patterns of students. This paper shows an education model that could be transferred and implemented in other educational contexts.

**Keywords:** Sustainable consumption patterns; sustainable curriculum; higher education; educational programme; pre-service teacher training.

## Introduction
Given the need to promote a more sustainable society, the leaders of the member states of the United Nations signed a commitment at the UN Millennium Summit in 2000 to achieve eight human development goals by 2015, which they called the Millennium Development Goals -MDGs-(WHO: World Health Organization, 2018). The eight MDGs are the following: eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/ AIDS, malaria and other diseases, ensure environmental sustainability and develop a global partnership for development.

This agreement was an unprecedented global mobilization and by the time the MDG era came to an end, as shown in the Final Report (UN, 2015a), millions of lives had been saved and conditions had improved for many. However, gender inequalities, large gaps between the world's poorest and richest households, highly vulnerable people who suffer from climate change and environmental degradation, major wars and conflicts that force people to flee their households and millions of people living in poverty and hunger persist.

The aforementioned successes must therefore be taken as an impetus to build and develop new goals for the future. In this regard, the United Nations adopted the 2030 Agenda for sustainable development in January 2016, after the 2015 deadline for the MDGs expired. It aims to improve and achieve the targets the MDGs failed to meet. The 2030 Agenda includes 17 integrated and indivisible Sustainable Development Goals (SDGs: UN, 2015b) that

combine the three dimensions of sustainable development: economic, social and environmental (Albareda et al., 2018; Francis, 2015; Lozano, 2008).

In the quest to achieve sustainable development, the role of education and educators at all levels and in all disciplines is crucial. Teachers contribute to helping future generations of citizens acquire a proper perspective of the problems and challenges that affect humanity and can intervene in the related decision-making processes (Vilches& Gil-Pérez, 2012).

Despite the fact that in 1990 the leaders of universities of the whole world, already aware of the unsustainability of the planet, signed the Talloires Declaration in Paris, in which they committed themselves to lead the struggle for a sustainable future, it was not until the celebration of the Rio de Janeiro Earth Summit in 1992 that this commitment to education, and university education in particular, materialized in specific actions through Agenda 21 (UN, 1992).

In 2002, given the lack of results and the great impact human activities continued to generate on their environment, the General Assembly of the United Nations adopted resolution 57/253, agreeing to proclaim the Decade of Education for Sustainable Development 2005- 2014 (UNESCO, 2005). Through this resolution, which insists on the need to address environmental problems from a global perspective, the reorientation of education is urged so that all people can have access to it and can learn lifestyles that improve society and promote a more sustainable future (Barrón, Navarrete & Ferrer-Balas, 2010).

In Spain, the Conference of Rectors of Spanish Universities (CRUE) created in 2002, and its working group on Environmental Quality and Sustainable Development (CADEP), aimed at promoting the integration of sustainability criteria in the university and inter-university cooperation in this area. In 2005, the Executive Committee of the group approved a document with guidelines for the inclusion of sustainability in university curricula (CRUE, 2005; revised in 2012).

This document sets out general criteria and recommended actions to include sustainability in the curricula of Spanish universities, within the framework of the European Higher Education Area, which proposes an opportunity for change. As pointed out by Barrón, Navarrete and Ferrer-Balas (2010), embedding sustainability into university curricula is not limited to the inclusion of environmental contents in the syllabi of the different subjects but it entails global changes in the educational process. Coinciding with the aforementioned authors, Vilches and Gil-Pérez (2012) point out that integrating sustainability into curricula implies the incorporation of knowledge, values and sustainability criteria in teaching and research as essential dimensions in the training of future professionals. Numerous Spanish universities have started to put this into practice, as evidenced by some recent works (Mulà et al., 2017; Fernández et al., 2016; Cebrian & Junyent, 2015).

This paradigm shift in the educational process acquires special relevance in pre-service teacher training because those future teachers will, from the different areas of their teaching activity, be the ones that will contribute to the education of the citizens of the future (Ull, 2015). The influence of teachers reaches far beyond the classroom and can contribute to building a more sustainable society. Not only do teachers have to be knowledgeable and deliver convincing arguments, their behavior needs to be consistent with what is taught in the classroom. Education in responsible consumption is considered a key element in environmental education, as evidenced by the fact that it is SDG 12 of the 2030 Agency (UNESCO, 2017; UN, 2015b; Wilk, 2002).

This paper, in line with UNESCO (2017), presents a proposal for a sustainable curriculum in the context of the subjects of mathematics and experimental science in pre-service teacher education programmes. Students learn about how their consumption habits impact on the planet and what kind of measures they can take to contribute to reducing said impact. This is the first step for students to adopt a pro-environmental attitude and begin to introduce small changes in their routines. The design of the proposal is competency-based learning as suggested by the European convergence process (González & Wagenar, 2003), since specific activities are included in the syllabi of the subjects. The students put to use knowledge, procedures, attitudes and values that lead to the

resolution of an environmental problem with sustainability criteria; what Geli de Ciurana and Leal-Filho(2006) and Wiek et al. (2011) call competencies for sustainability.

The objectives set for this study were (1) to find out about the consumption habits of the students and (2) to design a programme to generate a framework of reflection and to enhance a change of attitude based on the previously obtained results and, finally (3) to check the impact of the educational programme developed.

## Material & methods

### 2.1. Data collection and analysis

The test used for initial (diagnosis) and final data collection (impact of the teaching programme developed) was the same (see table 1). This test is a simple adaptation of the survey on habits and values related to sustainability, developed by the Barcelona City Council and the Institute of Governance and Public Policies (Fernández et al., 2018). It contains a total of 14 questions. The first twelve provide quantitative data on a numerical scale of 0-3 (0: never, 1: sometimes, 2: normally, 3: always) and the remaining two include qualitative responses of two types, unique response between different options provided (question 13) and open response (question 14).

***Table 1 Questionnaire used as pre-test and post-test to initial diagnosis and final impact analysis (Fernández et al. 2018).***

| Write the corresponding number: Always = 3, Normally = 2, Sometimes = 1, Never = 0 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Questions | | | | | | | Nº. |
| 1. Do you recycle household waste? | | | | | | | |
| 2. Do you recycle organic waste? | | | | | | | |
| 3. Do you try to print nothing more than what is essential? | | | | | | | |
| 4. Do you drop off used clothes in donation bins? | | | | | | | |
| 5. Do you dispose of used batteries and electrical appliances in specific recycling containers? | | | | | | | |
| 6. Do you take expired or unused drugs to the pharmacy or primary health care centre? | | | | | | | |
| 7. Do you try to reduce the consumption of water at home? | | | | | | | |
| 8. Do you try to save on heating costs in winter? | | | | | | | |
| 9. Do you turn off the lights when they are not needed? | | | | | | | |
| 10. Do you buy products without packaging? | | | | | | | |
| 11. Do you avoid pouring hazardous substances down the sink or the toilet? | | | | | | | |
| 12. Do you use energy-efficient electrical appliances? | | | | | | | |
| 13. Which means of transport do you normally use? | Public transport | Car-sharing | Car | Bike | Motor bike | Walking | Other |
| 14. What does sustainability mean to you? | | | | | | | |

A quantitative analysis of the data was carried out using SPSS v.22.00 and Excel 2016 computer programmes.

### 2.2. Sample

The educational proposal was carried out during the first semester of academic year 2017-2018. The groups of pre-service teacher students of the *Universitat Internacional de Catalunya* were the following:

(1) Group A: 29 third year students, educational programme through Mathematics (see tables 2a and 2b)
(2) Group B: 27 second year students, educational programme through Experimental Science (see tables 3a and 3b).

Although the groups of students belonged to different courses, both groups received training specifically designed to achieve the objectives of this work for the first time.

**2.3. Educational programme: formative proposal**

In accordance with the data collected in the initial diagnosis of the students, the programme was designed through mathematics (group A) or through experimental science (group B). The activities programmed were framed within the active methodologies of cooperative learning and project-oriented learning (Leal-Filho, Shiel &Paço, 2016; Pratt, 2003).

**2.3.1.** ***Training through mathematics (group A)***

Tables 2a and 2b shows the training activities carried out with group A and the learning objectives pursued through the subject of mathematics.

***Table 2a Training activities and learning objectives pursued through the subject of Mathematics***

| **Activities** (Groups of 4-5 students) *(See table 2b for details)* | **Learning Objectives** (In line with the objectives designed for this subject) | **Related consumption habits** |
|---|---|---|
| 1. Title. *What are clothes made of?* | 1.Think about the water consumption in the textile industry and the environmental implications of the waste generated<br><br>2. Think about the options for recycling the material used in the manufacture of clothing: synthetic fiber, natural fiber, buttons, zips, etc. | Water consumption<br><br>**Drop off used clothes in donation bins** |
| 2. Title. *Mysteries uncovered: the electricity and water bills* | 1. Know and solve problems related to daily life and consumption in homes.<br><br>2. Discover mathematics can be an instrument to measure and promote the responsible consumption of electricity and water in homes. | Electricity consumption<br><br>Water consumption |
| 3. Title. *Medication goes back to the pharmacy* | 1. Know the medication collection containers for recycling, where they are located, how they are transported and where they are going.<br><br>2. Find out what the consequences are of throwing medicines in the ordinary trash. | **Take expired drugs to the pharmacy or primary health care centre** |
| 4. Title. *Mathematics in the market. Consumption of local food* | 1. Know the nearest market.<br><br>2. Raise awareness about the habit of using recyclable bags or straw baskets.<br><br>3. Think about the reasons why the price of the same product varies according to the place of purchase. | **Buy products without packaging** |

***Table 2b Details of the activities developed through Mathematics***

| Activities | Procedure |
|---|---|
| 1 | – Presentation of different kinds of fabrics.<br>– Find out how they are obtained and what the water consumption is in each case.<br>– Examine the amount and type of waste generated depending on the raw material used in their manufacture.<br>– Inquire about the average annual expenditure of Catalan families on clothes and the consumption of second-hand clothes in the Community. |
| 2 | – Presentation of electricity and water bills from different households and review of the meaning of the different concepts that appear in them.<br>– Finding out the average consumption and the possibilities of saving energy and money with LED light bulbs.<br>– Study of the energy and water consumption of washing machines, dishwashers and other home appliances. Energy-efficient appliances.<br>– Presentation of different kinds of water consumption in the shower depending on: without filter, with a filter or with a water-air diffuser.<br>– Calculate the amount of money a family saves per year taking showers with a water-air diffuser and without any type of filter. |
| 3 | – Design and plan a project for a children's camp.<br>– Include a first aid kit in the luggage.<br>– Review the kit to replace the expired medication.<br>– Go to the pharmacy to buy new medicines and deposit the expired ones in medication collection containers. |
| 4 | – Go to the market and buy fruit and vegetables the type and quantity of which will be fixed in advance.<br>– Ask for and note down the origin of each of the products and look for the location on a map.<br>– Select the same product purchased in the market, supermarket and hypermarket and compare the price. |

### 2.3.2. *Training through experimental science (Group B)*

Tables 3a and 3b shows the training activities carried out with group B. These activities were designed based on the results of the initial diagnosis and accordingly with the learning objectives pursued through the experimental science course.

***Table 3a Training activities and learning objectives pursued through the subject of Experimental Science***

| **Activities** (Groups of 4-5 students) (See table 3b for details) | **Learning Objectives** (In line with the objectives designed for this subject) | **Related consumption habits** |
|---|---|---|
| 1. Title. *A vegetable garden for the community: possibilities of self-supply; healthy food for all.* | 1. Know how to create, manage and maintain a vegetable garden.<br><br>2. Understand how to supply a community with needs, and what equitable distribution of food means. Know the implications of food waste.<br><br>3. Understand the concept of sustainable food; reduced amount of meat in diets, consumption of local and seasonal products. | **Buy products without packaging**<br><br>Water consumption<br><br>Recycle organic material |
| 2. Title. *Organic farming: no pesticides or chemical herbicides, efficient use of water* | 1.Know the principles of ecological agriculture and understand the environmental, social and economic implications of the misuse and contamination of water and soil.<br><br>2Become familiar with efficient use of water, its savings and recycling possibilities. | **Buy products without packaging**<br><br>Water consumption<br><br>**Take expired drugs to the pharmacy or primary health care centre** |
| 3. Title. *Use of domestic organic waste: the planet cannot absorb all our waste* | 1. Know how organic material is recycled and how to obtain quality fertilizer.<br><br>2. Know the mechanisms of domestic composting and its benefits. | Recycle organic material |
| 4. Title. *What's behind the label of a piece of clothing?* | 1. Know the ecological implications of cotton cultivation and other fibers used in the textile industry<br><br>2. Know the socio-economic impacts of clothing manufacturing in underdeveloped or developing countries | **Drop off used clothes in donation bins** |

***Table 3b Details of the activities developed through Experimental Science***

| **Activities** | **Procedure** |
|---|---|
| 1. | – Creation of mini plots for each group.<br>– To plant different seasonal vegetables per plot.<br>– Study of the supply needs of each group and mechanisms to exchange products between groups. |
| 2 | – Installation of a basic system of drip irrigation in each plot and collection of rainwater (drums).<br>– Manual removal of herbs and preparation of natural pesticides. |

| | |
|---|---|
| 3 | – Collection of organic remains from different services of the Campus and from students' homes.<br>– Gather vermicomposting and start a compost heap in the garden; use of organic waste obtained previously. |
| 4 | – Select different items of clothing.<br>– Locate the label of these garments, read them and write down: where they have been manufactured, what materials have been used and if they present any type of ecological seal.<br>– Share the collected data and discuss the following questions: why are they manufactured in underdeveloped or developing countries? What are the implications of growing cotton? What materials are more respectful with the environment? Why? |

## Results

### 3.1. Initial diagnosis

As can be seen in table 4, before the teaching proposal, the students stated, both in group A and group B, that their most frequent sustainable habits were the following:

(1) Turn off the lights when they are not needed
(2) Print only what is essential
(3) Save on heating costs in winter
(4) Dispose of special waste such as batteries and electrical appliances in specific recycling containers

In the case of the first indicator, 'turn off the lights when they are not needed', the median value (Me) stood at 3 for both groups (A and B) and with a low dispersion ($SD_A = 0.47$; $SD_B = 0.742$), which indicates that most of the students "always" do it.

Regarding the second point, "print only what is essential", the median varied between 2.5 for group A ($SD_A = 0.841$) and 3 for group B ($SD_B = 0.802$). These data put the level of compliance of this indicator between "almost always" and "always" respectively, for most part of the respondents.

As for indicator three, "save on heating costs in winter", and four, "dispose of special waste such as batteries and electrical appliances in specific recycling containers", the Me varied between 3 for both indicators in group A ($SD_A = 0.928$ and $SD_A = 1.081$ respectively) and 2 for both indicators in group B ($SD_B = 0.997$ and $SD_B = 1.177$ respectively). In the first case, most of the students "always" had these habits and in the second, they "normally" had them. These results seem to indicate that, in relation to these four kinds of behaviour, an educational proposal does not seem urgent. The findings indirectly reflect students are aware of the consequences of their actions and of the impact they have on the environment.

Their least frequent sustainable habits were as follows:

(1) Take expired drugs to the pharmacy or primary health care centre
(2) Drop off used clothes in donation bins
(3) Buy products without packaging

In the case of the first point, 'take expired drugs to the pharmacy or primary health care' *centre*, the result obtained is alarming, since most of the students answered "never" in both groups and with a similar dispersion (Me = 0 for A and B; $SD_A = 1.280$; $SD_B = 1.188$).

Regarding the other two points, "drop off used clothes in donation bins" and "buy products without packaging", the majority answered "never" in the case of group A (Me = 0 for both indicators $SD_A = 1.195$ and $SD_A = 0.686$

respectively) or "sometimes" in the case of group B (Me = 1 for both indicators $SD_B$ = 1.074 and $SD_B$ = 0.859 respectively).

These results show the urgent need of an educational programme to influence student behavior related to these indicators.

In an intermediate position between the most and least frequent habits, with a level of compliance, most of the students in the two groups (A and B) replied "normally" (Me = 2 for all indicators), to the questions related to the following habits:

(1) Recycle organic material ($SD_A$ = 1.298; $SD_B$ = 1.182) and household waste ($SD_A$ = 1.081; $SD_B$ = 0.93).
(2) Avoid pouring hazardous substances down the sink or the toilet ($SD_A$ = 1.125; $SD_B$ = 1.141)
(3) Use energy-efficient electrical appliances ($SD_A$ = 1.018; $SD_B$ = 0.759)
(4) Try to reduce water consumption at home ($SD_A$ = 1.091; $SD_B$ = 1.155)

These results indicate an acceptable level of commitment and, therefore, although educational activities have been worked on with the students, these habits seem to be quite integrated in the groups under study.

In question 13: What means of transport do you normally use? figure 1 shows the answers of group A and group B. In the first case, both public transport and the car for individual use represented 26% of the answers, followed by 24% of students sharing a car, 15% walking, 7% using a motorbike and 2% a bicycle. In the second case, public transport accounted for 43% of the responses, followed by 25% of students travelling on foot, 13% by motorbike, 12% in shared cars and 7% in individual cars. No student reported travelling by bicycle.

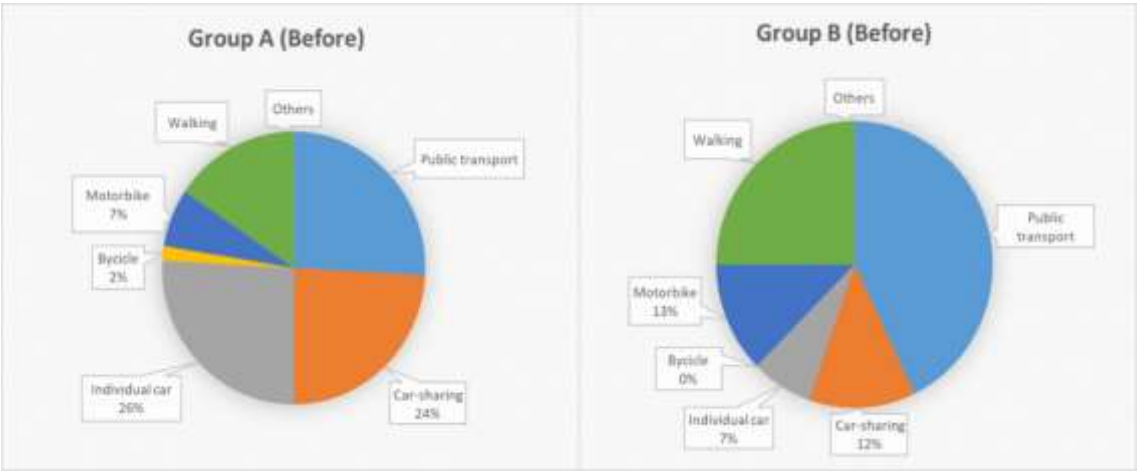


***Figure 1: Students' answers to the question: what means of transport do you normally use? before the educational programme***

Table 5 summarized some answers obtained to question 14: What does sustainability mean to you? in both groups (A and B).

***Table 5 Some students' answers to the question: what does Sustainability mean to you? before the programme***

| **What does Sustainability mean to you? (Before)** | |
|---|---|
| **Group A** | **Group B** |
| – Caring for the environment to prevent its pollution and destruction<br>– It's the fact of respecting the environment.<br>– To use resources in a way to keep the planet in good condition | – Small gestures and details to avoid unnecessary and unfair treatment of the environment<br>– Help the environment to restore what we have destroyed |

| | |
|---|---|
| – It is an act of gratitude to nature, returning an equitable treatment to all that it gives us.<br>– To be responsible for the world thinking about the future<br>– To keep resources in balance | – Do not cause irreparable damage to the planet<br>– Any personal, group and state initiative with the aim of sustaining the environment<br>– Be careful with the waste we produce. Be consistent with our actions towards humanity |

**3.2. Results after educational training. Impact of the educational programme**

Table 6 shows the results after implementing the programme. In general, the most and least frequent actions carried out and those in the intermediate positions remain the same as before performing the activities.

***Table 6 Descriptive statistics of the Mathematics (A) and Science (B) groups after carrying out the educational programme***

| After implementing the educational programme (intervention impact) | Group | N | Me | Average | SD |
|---|---|---|---|---|---|
| Do you recycle household waste? | A | 29 | 2 | 1.847 | 1.078 |
| | B | 27 | 2 | 1.777 | .891 |
| Do you recycle organic material? | A | 29 | 2 | 1.789 | 1.182 |
| | B | 27 | 2 | 1.592 | 1.185 |
| Do you try to print nothing more than what is essential? | A | 29 | 3 | 2.570 | .606 |
| | B | 27 | 3 | 2.296 | .912 |
| Do you drop off used clothes in donation bins? | A | 29 | 1 | 1.315 | 1,002 |
| | B | 27 | 1 | 1.259 | 1.347 |
| Do you dispose of used batteries and electrical appliances in specific recycling containers ? | A | 29 | 2 | 2.210 | 0.917 |
| | B | 27 | 2 | 2.037 | 0.979 |
| Do you take expired or unused medication to the pharmacy or primary health care centre? | A | 29 | 1 | 1.421 | 1.216 |
| | B | 27 | 1 | 1.333 | 1.330 |
| Do you try to reduce the consumption of water at home? | A | 29 | 2 | 1.947 | 1.129 |
| | B | 27 | 2 | 1.555 | 1.050 |
| Do you try to save on heating costs in winter? | A | 29 | 3 | 2.625 | .597 |
| | B | 27 | 2 | 2.185 | .921 |
| Do you turn off the lights when they are not needed? | A | 29 | 3 | 2.812 | .403 |
| | B | 27 | 3 | 2.777 | .640 |
| Do you buy products without packaging? | A | 29 | 1 | 1 | .816 |
| | B | 27 | 1 | .852 | .907 |
| Do you avoid pouring hazardous substances down the sink or flushing them down the toilet? | A | 29 | 2 | 2.062 | 1.124 |
| | B | 27 | 2 | 2.000 | 1.037 |
| Do you use energy-efficient electrical appliances? | A | 29 | 2 | 1.812 | 0.916 |
| | B | 27 | 2 | 1.963 | .897 |

By focusing especially on the three weak points detected in the initial diagnosis and on which greater emphasis was placed during the educational activities (in both itineraries, see tables 2 and 3), it was observed that in all cases the median either remained unchanged or increased, maintaining a similar dispersion (see figure 2).

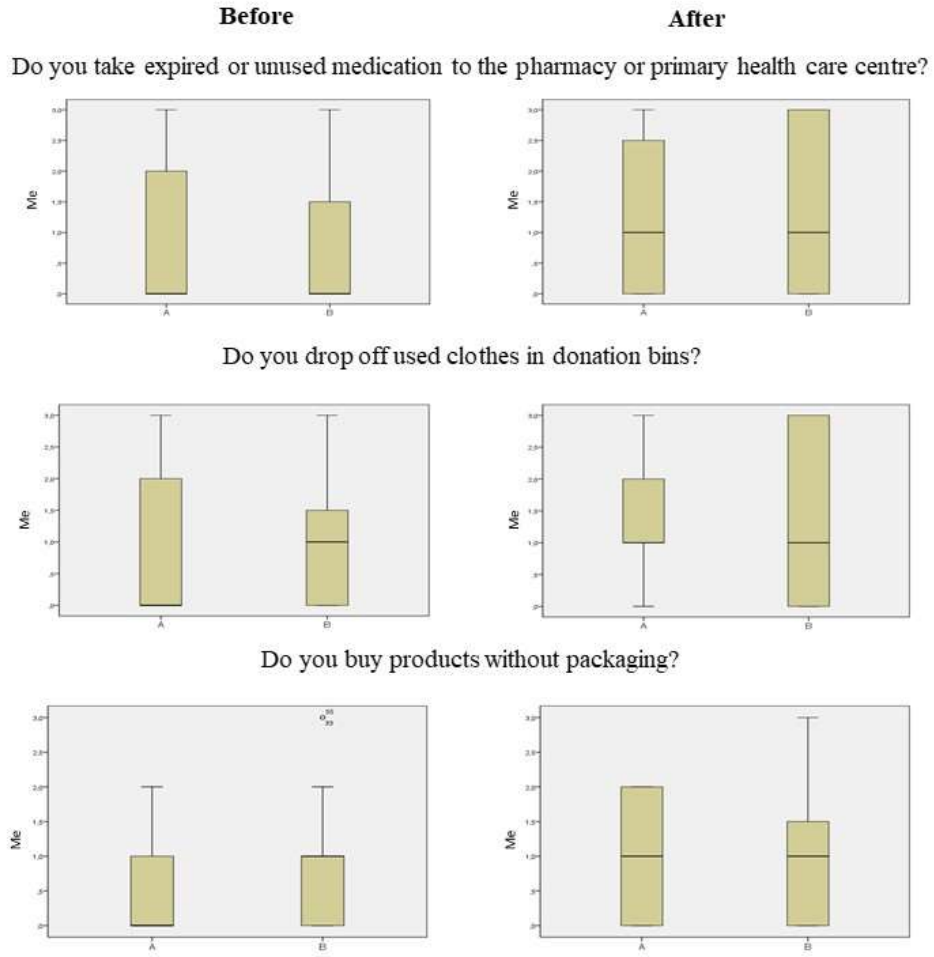


***Figure 2: Box-plot of the three sustainable actions students (of both groups) perform the least frequently before and after the educational programme***

As can be seen in figure 3, notable changes were observed in relation to the means of transports that the students of both groups use more frequently. While for group A, before the activity, public transport accounted for 26%, it rose to 33%. The second position was shared between the individual use of the car and travelling on foot (21% in both cases), moving up from the fourth to the second position, ahead of the shared car (16%). The last positions remained unchanged: travel by motorbike (7%) and by bicycle (2%). In the case of group B, although the use of public transport decreases (from 43% to 34%), the difference is assumed by car sharing that goes up from 12% to 21% and transport on foot, which increases from 25% to 30%. It is striking to see the low number of students who, both before and after, travel by private car (7% and 6% respectively).

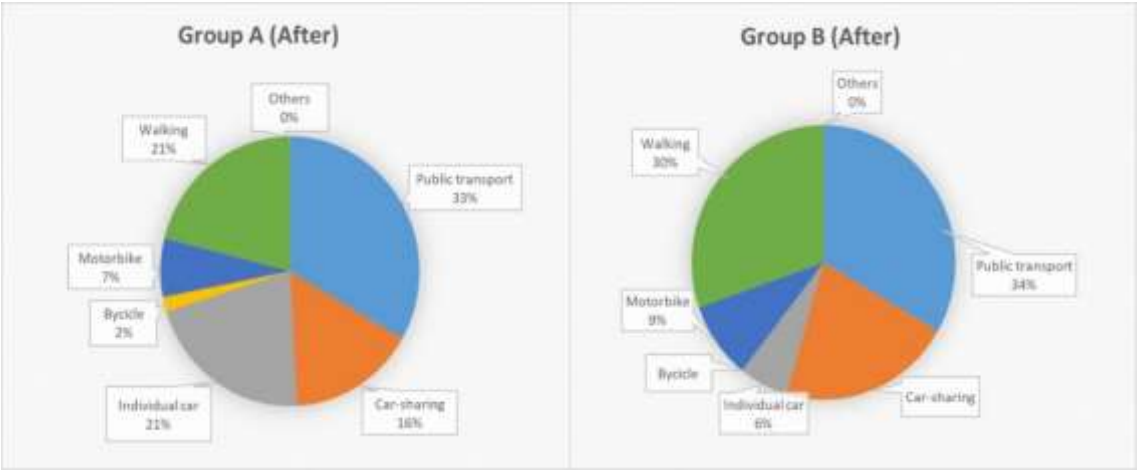


***Figure 3: Students' answers to the question: what means of transport do you normally use after the educational programme?***

Finally, regarding the question that was asked again about what sustainability meant to them, table 7 shows the answers that differ from those provided in the initial diagnosis.

***Table 7 Students' answers to the question: what does Sustainability mean to you? after the programme***

| What does Sustainability mean to you? (After) | |
|---|---|
| **Group A** | **Group B** |
| – Analyze the economic, social and/ or ecological conditions related to the environment that we are damaging. | – It is the relationship between economic, social and ecological aspects to reach human needs but maintaining the planet's biodiversity.<br>– To live well with what we have, without exceeding ourselves and without harming future generations, to maintain a balance between society and nature<br>– It consists in satisfying the needs of the population without endangering the resources for subsequent generations, taking into account economic, environmental and social aspects. |

## Discussion and conclusions

Living in a sustainably way requires using resources at a pace that allows their renewal. However, our society, oriented to consumption, supposes enormous pressure on the Earth. The citizens of the European Union constitute less than 10 % of the world's population and, nevertheless, they consume 50 % of the meat, 25 % of the paper and 15 % of the energy (European Commission, 2010). In Spain, the ecological footprint of its population indicates that to maintain this rate of consumption, we would need two planets and a half free of inhabitants, in addition to the current one, or what is the same, around 4 global hectares (hg) per capita, while, according to the biocapacity of the Earth, only 1.7 hg corresponded to us (WWF, 2016). In Catalonia, the difference between the biocapacity of its territory and the ecological footprint of its inhabitants shows that there is an average ecological deficit of more than 4 hg, with a severe deficit in the city of Barcelona, which would need an area 83 times larger to maintain its level of consumption (Facua Andalucía, 2009).

Considering the data on personal consumption of Europeans and Spaniards in general, and Catalans in particular, the results obtained in this work showed three particularly weak aspects in the students' consumption habits: (1) to take expired drugs to the pharmacy or primary health care centre, (2) to drop off used clothes in donation bins and (3) buy products without packaging. At the beginning of the activities developed, they had never performed

those actions and, at the end, they occasionally did, either addressing the problems from mathematics (activity programme table 2) or from experimental science (activity programme table 3).

Regarding the first point, expired medicines represent a highly contaminating factor for the final disposal sites of Urban Solid Waste (USW). There are studies that show 58.3 % of expired drugs eliminated as USW could be used for veterinary therapy, which would be of great importance in the field of public health, since it would reduce the possibilities of zoonoses, especially in underdeveloped or developing countries. From an environmental perspective, the reduction of contamination by dumping medicines, favors the biodegradation of open dumps and increases the speed of biogas generation (Kiss & Encarnación, 2006).

In addition, Spain is a large consumer of medicines. In 2011, more than 1.000 million prescriptions were issued in the Spanish public health system, an average of 21 prescriptions per person/ year (Federación Empresarial de Farmaceúticos Españoles, 2017). Given this circumstance, and to promote recycling expired medicines in Spain, the pharmaceutical sector created an Integrated System of Management and Collection of Containers -SIGRE-, whose objective is to give a specific environmental treatment to household medication waste (SIGRE, 2016). That is the reason why many health centres and pharmacies have the so-called SIGRE points that provide specific containers where these medicines can be deposited. It is possible the students did not have any information about this initiative, which started more than a decade ago. After the training received, a change was observed in both groups from "never" taking expired drugs to the pharmacy or health care centre to "sometimes".

In relation to recycling used clothing, it is important to point out that the fashion sector ranks third in the priorities of young Europeans after eating and spending leisure time with friends (Generalitat de Catalunya, 2013). Of all the countries analyzed, Spain and the United Kingdom are the ones with the highest number of young people who spend between 50 and 80 euros a month on fashion. This consumption has been favored by the immense growth of the textile industry and the "fast fashion" trend of important brands, which change their offer and launch new collections in very short periods of time at affordable prices (López, 2012). This high level of consumption has linked this generation of young people to large quantities of waste, both in pre- and post-consumption stages (Pensupa et al., 2017).

The textile industry is one of the most polluting due to the chemical products used and the large amounts of water it requires. Between 10 and 20 % of all textile products are remains of materials that are wasted. The reprocessing of materials such as wool, cotton, and polyester into new yarns and fabrics, or repurposing of garments through reconstruction or other secondary uses does save energy, water, and carbon emissions as compared to fabric and garment production from "virgin" materials (Wang, 2006; Farrant et al., 2010; Weller, 2013). At the post-consumer stage of the life cycle of clothes, their remains are a mixture of natural fibers, synthetic fibers and accessories such as buttons, zips, etc. which makes their degradation very difficult (Payne, 2015). These remains can be recycled, but of the 13 million tons accounted for in 2010, only 15 % were recovered (Joung& Park-Poaps, 2013; Wallander, 2012).

In this work, the students in group A manifested mostly they never performed this gesture and those in group B, "sometimes". At the end of the programme, group A was equal to B and the latter remained. It is clear that it is still necessary to further explore this aspect. Therefore, it is very important to inform and educate young people about the possibility of depositing used clothing in special containers for subsequent categorization and different ways of recycling, from reusing garments to selling them to recycling industries (Bediako, Wei & Yun, 2016, Binici et al., 2010).

In relation to the third aspect, buying the exact amount of food needed saves money and also avoids the waste of it. While 79 million people live below the poverty line in the European Union (Official Journal of the European Union, 2013), and 16 million of them receive food aid from charitable organizations, it is estimated that each year more than 1.3 billion tons of food in good condition are wasted in the world, 89 million tons in Europe and 8 million tons in Spain (European Commission-BIO Intelligence Service, 2010). Buying bulk products would decrease the consumption of petroleum, $CO_2$ and other gas emissions generated in manufacturing packaging. According to the Environmental Protection Agency, which promotes the Green Lights and Energy Star

programmes, each kilowatt-hour of electricity that is not used avoids the emission of 680.38 grams of $CO_2$, 5.8 grams of $SO_2$ and 2.5 grams of Nox (As cited in: Government of Chile, 2002). In addition, emissions derived from long-distance transport of manufactured products would be avoided (Palmarola, 2015) and the development of local commerce would be enhanced. In Europe, Italy (Rete Effecorta), Germany (Original Unverpackt) and England (Unpackaged) lead supermarket initiatives that offer bulk products, including not only food, but other products such as laundry detergent or shower gel. Over the last few years, there has been a proliferation of shops selling bulk products in Spain. Companies such as Granel (which means bulk in Spanish and Catalan), founded in 2012, have numerous shops in the province of Barcelona and in the Balearic Islands.

The results obtained in this study revealed that students who, at the beginning of the programme never (A) or occasionally (B) consumed this type of products, consumed them only occasionally afterwards (in both groups). This coincides with scientific studies conducted in Spain, which show secondary school and university students are characterized by a carefree lifestyle both with regard to the type of food they eat and their health (Sánchez et al., 2002). However, it is surprising to see that these same consumers stated that the ideal product is the local, ecological, cheap product purchased in bulk (Sánchez et al., 2002; Sánchez, Gil & Gracia, 2000).

As for the most common means of road transport chosen by the students, after the programme they modified their preferences. All of them changed to means that are more respectful with the environment. Road transport which here refers to private and public transport of people, is a sector of significant socio-economic importance. There are estimates that set their contribution to the Gross National Product (GNP) of Spain at 7 % on average (Sotelo et al., 2011). At the same time, this supposes a huge cost to the environment and to human health (Gurjar et al., 2008; Colvile et al., 2002; Adams et al., 2002). Road transport accounts for more than 25 % of $CO_2$ emissions, with an annual increase of 1.9 % in the case of passenger transport. In terms of energy consumption, private vehicles represent around 50 % of total road transport consumption in Spain, and only 3 % corresponds to collective passenger transport (Sotelo et al., 2011). Although these are the average data for the country, the data obtained in this work show less preference for the use of the private vehicle compared to public transport, but with large differences between the two groups of students analyzed.

At the beginning of the educational programme, in group A, the majority preference was shared between the individual use of the car and public transport with 25% of representation each. However, in group B, most students chose public transport, with a very low percentage of those who used the car. After the programme, group A dramatically reduced the use of the car and increased the use of public transport and walking. In group B, public transport continued to be the majority, but some students moved to the alternative of car sharing or traveling on foot. In both cases, the educational programme caused a change in their habits towards options that are more respectful with the environment.

In the case of car sharing, in Spain, the General Direction of Traffic (Ministry of Home Affairs, 2016) has developed a plan to promote this alternative in the largest cities, Madrid and Barcelona, offering special lanes on motorways to reduce traffic congestion (lanes for High Occupancy Vehicle, VAO in Spanish). Likewise, discounts of up to 40 % are applied on some motorways for vehicles with three or more occupants, which has also influenced their preferences (Abertis company, n. d.).

With respect to the question on what they understand by the word “sustainability”, the answers of the students of both groups are similar before receiving the training and all of them include the verbs " care", "keep", "respect" in relation to “the environment", "our planet" or "the world in which we live". The change that can be detected after the training is perceived in the answers of some students (included in table 6), which appear most frequently in group B (approach to the problem from Experimental Science), and which begin to include the three dimensions of sustainability, not just the environmental one, working in a holistic way (UE4SD, 2015).

The students seem to begin to understand that the word “sustainability” transcends the environment, since it not only includes the search for environmental quality, but also equity and social justice. It implies knowledge and a range of skills for action, including ethical criteria (Martínez-Agut et al., 2007). Previous studies of the research group showed students acquire more awareness and are more willing to change their habits when they are

approached from an environmental perspective (Fernández et al., 2016) and pro-environmental actions were promoted based on the Norm Activation Model (Schwartz & Howard, 1981), making students aware of these relevant problems and indicating what they could do to alleviate them.

Based on the objectives set for this work, it can be concluded that:

(1) The students of both groups show a similar pattern of consumption in the initial diagnosis, highlighting that:

(1.a) The three actions they performed with less frequency were to take expired drugs to the pharmacy or primary health care centre, to drop off used clothes in donation bins and to buy products without packaging.

(1.b) In both groups, the most sustainable forms of transport, travelling by bicycle and walking, are hardly represented or not represented (between 0-2 % for the first one and between 15-25 % for the second).

(1.c) All the students state that the word "sustainability" is linked to the environment's protection and respect.

(2) The educational programme -sustainability activities organized in the subjects of experimental science and mathematics- specifically designed to influence the weakest aspects detected, slightly improved their sustainable habits and seems, indirectly, that students start to understand that the word sustainability transcends the environment, including social and economic aspects in its definition.

(3) Although educational programmes, such as the one presented in this paper, help students change their attitude for the better, it is still necessary to further explore sustainable consumption for the students to integrate it naturally in their way of doing and living.

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