

1 Article

## 2 Cultural Sustainability in Ethnobotanical Research 3 with Students up to K-12

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10 **Abstract:** In the achievement of the Sustainable Development Goals (SDGs), education plays a  
11 fundamental role. However, traditional methodologies do not favor the enrichment and personal  
12 development essential to promote global awareness. The use of active methodologies based on  
13 experiences improve the quality of learning. This work describes the design, implementation, and  
14 evaluation of the acquired knowledge of a didactic proposal for non-formal education as a support  
15 for regulated education based on botany content. Firstly, a workshop was held, where young people  
16 participated directly in developing field work with a real scientific methodology. Subsequently, a  
17 group of students was chosen to be interviewed to obtain a global vision of the learning they  
18 obtained. The motivation of the students was quite positive, which allowed us to obtain voluntary  
19 participation in the field work and gave the students a participative attitude throughout the  
20 development of the workshops. Four months later, this positive attitude remained during their  
21 direct involvement in various activities, and the students still remembered the fundamental content  
22 discussed. Relating the didactic proposal to its immediate environment was shown to increase  
23 interest in learning and value in its own context. The results of this educational experience have  
24 been very positive, as knowledge was acquired, and interest in the preservation of the environment  
25 and the profession of a researcher was promoted.

26 **Keywords:** active methodologies; Sustainable Development Goals; non-formal education;  
27 Ethnobotany; learning assessment; STEM  
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### 29 1. Introduction

30 Today, society demands new educational methodologies that encourage the active participation  
31 of the student, unlike traditional methods where the teacher is the protagonist [1]. Another modern  
32 issue is sustainability. This concept is an indisputable need that must be integrated into multiple  
33 fields, including teaching [2].

34 Since 1992, UNESCO (United Nations Educational, Scientific and Cultural Organization) has  
35 recognized and promoted education as a basic right for the promotion of sustainable development,  
36 but it is in the new World Agenda for Sustainable Development 2030 that this vision is made evident.  
37 In this document, education appears both as a specific goal and as a means to achieve all the  
38 Sustainable Development Goals (SDGs) [3].

39 Education is the basis for promoting development, but it is also essential for personal enrichment,  
40 endowing individuals with skills and values and enabling them to be more versatile, critical, and  
41 resolute. In other words, developmental education facilitates an understanding between  
42 globalization and development by helping promote awareness of "global citizenship" [4]. The success

43 of education would entail improvements in employment and reduce depopulation—problems that  
44 mainly affect rural areas.

45 Here, the terms "education" and "sustainable rural development" intersect. Rural development  
46 refers to the need to establish a business fabric to make a territory strong and avoid problems such  
47 as population loss, emigration, aging, and poor economic diversity.

48 Initiatives are needed to adapt to the needs and constant changes that occur in society, thereby  
49 responding to the aforementioned problems, improving the standard of living of the inhabitants of  
50 rural areas, and helping to exploit and develop their sustainable environment [5].

51 The sociocultural context surrounding an individual is, in itself, a didactic technique that directly  
52 influences the learning process [6]. Students learn more effectively when using active methods and  
53 content similar to their daily lives and interests. Therefore, including traditional knowledge as an  
54 object of learning [7] can contribute to the perceived value of one's "own culture", which in turn is  
55 important for sustainable development, allowing people to harness their wealth to build their future,  
56 transforming it into processes of solidarity and popular economy [8].

57 Although many previous experiences already show the positive impact of non-formal education  
58 [9,10], there are few references that focus on an inclusive way to promote so-called integral  
59 sustainability [11]—that is, an integrative vision of sustainability beyond environmental and  
60 ecological aspects. Thus, the current work presents a didactic experience that is primarily related to  
61 three of the SDGs and some of their goals: 4. Ensuring inclusive, equitable, and quality education and  
62 promoting lifelong learning opportunities for all (Quality Education), in the sense that it is necessary  
63 to ensure that all students acquire the knowledge required to achieve sustainable development; 12.  
64 Ensure sustainable consumption and production modalities (responsible production and  
65 consumption) due to the need for the efficient use of natural resources and waste reduction in order  
66 to achieve a more harmonious existence alongside the environment; 15. Sustainably manage forests,  
67 combat desertification, stop and reverse land degradation, and halt biodiversity loss (life of terrestrial  
68 ecosystems) to conserve our forests and biodiversity [12].

69 The scientific education of the population is essential for the transition to sustainability. Only in  
70 this way can we gain an understanding of the seriousness of the problems facing our planet and our  
71 way of life and train future scientists capable of developing more efficient resources and citizens  
72 committed to achieving a sustainable society [13].

73 However, to accomplish this goal, changes must be made in the traditional education system,  
74 moving from the present transmissionist tendency towards a more constructivist teaching pedagogy  
75 [14]. Teaching methodologies with the teacher at the center are still used in many disciplines,  
76 especially science. However, there is already evidence that the use of experience-based  
77 methodologies improves the quality of learning [15]. These principles are the base of new science  
78 education approaches, such as the systematic integration of different science-related subjects in an  
79 entire knowledge construct as STEM or even including arts in STEAM.

80 Although human beings are born with the instinct to observe, discover, and create, as we become  
81 adult, that desire to investigate becomes disconnected. Many young people have the preconceived  
82 idea that science is boring, difficult, and does not ensure a well-paid job in the future [16]. Among  
83 the main causes for a negative assessment of science is the organization of the educational system  
84 itself, as well as the poor relationship between the subject of study and daily lives of students [17,18].

85 As early as the 1980s, the need to develop the "scientific and technological literacy" of society  
86 was promoted to ensure that all citizens are able to make decisions on social issues in a democratic  
87 and responsible way [19]. Although actions have been taken since then, there is still a disconnect  
88 between what is planned and what is taught in the classroom. There is also a tendency to continue

89 using traditional teaching methods [20]. An academic transformation at different educational levels  
90 is still needed, requiring new, more active and realistic teaching programs and methodologies.  
91 Disinterest in science also affects the field of botany, showing a downward trend in botanical  
92 vocations in the university. However, vegetables are an available and attractive teaching resource to  
93 promote a positive view of the sciences. This task is in the hands of educators. For students to develop  
94 an interest in science, the teacher must play a key role from an early age. To carry out this task,  
95 training in science is essential [21]. Sometimes the scientific training received by teachers is limited,  
96 which represents an obstacle in the teaching of the natural sciences [22]. Direct collaboration between  
97 teachers and researchers is essential for the teacher's own training, as well as for the development of  
98 an integrated scientific curriculum [23].

99 The current article is focused in analyzing an educative experience that will be described below, with  
100 the following objective: To analyse the impact of a non-formal education activity on knowledge  
101 acquisition according to the framework for teaching Sustainable Development Goals (SDGs)  
102 according to an integral sustainability vision framework, as proposed by Zamora-Polo and Sánchez-  
103 Martín [11].

104 This general objective can be split into several research questions:

105 Question 1: Does a non-formal activity inserted into a standard academic space (a high school)  
106 have a positive impact on the knowledge acquisition of botanical and ethnobotanical concepts?

107 Question 2: Can a non-formal activity, if designed according to an integral sustainability vision  
108 framework, develop positive attitudes towards traditional knowledge preservation?

109 Question 3: Can a non-formal activity, if designed with close collaboration between secondary  
110 teachers and university researchers, promote the core concepts of the nature of science, such as what  
111 science is for and what kind of person a scientist is?

112 This research is structured in two phases. The first is the design and implementation of a didactic  
113 proposal that aimed to raise awareness among young people about the importance of preserving  
114 their ethnobotanical heritage and valuing it as a resource for sustainable development by involving  
115 the students in a realistic scientific study. The second phase examines, through interviews, the impact  
116 of this proposal on the achievement of the goals after a period of 4 months.

## 117 2. Materials and Methods

### 118 2.1. Relevance of the location

119 This work is part of a larger piece of research focused on the town of Hornachos, located in the  
120 autonomous community of Extremadura (Spain), adjacent to the protected area "Sierra Grande de  
121 Hornachos" included in the Natura 2000 Network [24].

122 The environmental richness of this area is important [24] but is not the only reason we chose the  
123 area for this work. This environment brings together several features that make it especially  
124 interesting. On the one hand, it has great cultural richness resulting from its historical past featuring  
125 various cultures, such as Roman, Jewish, Arab, and Moorish. On the other hand, it has a great  
126 diversity of plants associated with traditional knowledge and uses [25].

127 However, this rich heritage is being lost due to the increase in intensive agriculture and  
128 globalization, leading to the abandonment of natural resources [26,27].

129 Many authors have already noted the importance of education as part of a developmental  
130 process to promote integral sustainability [28]. It is a challenge to include the conservation of rural  
131 areas and their ethnobotanical identities (understood as cultural and social heritage) in an educative  
132 proposal. This process requires the development of skills and experiences that enable the construction  
133 of learning based on an assessment [29].

134

135 2.2. The educative center: Institute of Secondary Education (I.E.S) "Los Moriscos"

136 The I.E.S. Los Moriscos is located in the village of Hornachos, in the province of Badajoz  
137 (Extremadura) (Figure 1). This area was selected for its particular features, as Hornachos sits on the  
138 boundaries of the protected area of "Sierra Grande de Hornachos", which has several protection  
139 catalogs both regionally (Regional Zone of Interest (RZI)) and internationally (the Site of Community  
140 Importance (SIC), Special Protection Area for Birds (SPA), and Special Area of Conservation (SAC)),  
141 which are included in the Biodiversity Conservation Network of the European Union [30]. This area  
142 stands out for its cultivated varieties of wild plants with a rich historical-cultural legacy [31].



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**Figure 1.** Location of the town of Hornachos in Extremadura, Spain.

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146 It should be noted that the school in this area is a publicly owned rural secondary education  
147 institute created in 1997 and attended by students from various localities adjoining the protected area  
148 of "Sierra Grande de Hornachos", but the largest percentage is composed of young people from the  
149 town of Hornachos.

150 According to the corresponding data for the academic year of 2018–2019, the period of the  
151 first part of this study corresponding to the teaching workshops, the Center consisted of 368 students  
152 distributed at the Secondary Education levels, including those in a baccalaureate in the modalities of  
153 sciences, technology and humanities, and social sciences and those in the formative cycle of the  
154 middle degree, "Attention to people in situations of dependence". In addition, the Centre had a staff  
155 of 48 teachers and 9 members of non-teaching staff working as computer scientists, administrators,  
156 concierges, social educators, etc.

157 This Center has a "low" socioeconomic level [32], and most of the students' families live off  
158 agriculture, livestock, or construction. In addition, the immigrant rate is low, and no significant  
159 differences were found in either socioeconomic conditions or cultural and religious ones.

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2.3. Participating students

162 The entire design of the educative intervention was done on the basis of a tight collaboration  
163 with the teachers. Based on a prior agreement with the Center's teaching and management team, K-  
164 9 students were distributed into 4 groups, totaling 72 young people between the ages of 13 and 16.

165 This level was chosen because of its near-adult cognitive development and proximity to the  
166 end of compulsory studies, as determined by the Spanish administrations [33]. Since it did not  
167 inconvenience the workshop objectives, the representation of students from locations other than  
168 Hornachos was not taken into account because of their small representation and because this study  
169 was not interested in excluding certain students but in arousing interest in research, the value of one's  
170 own resources, and the promotion of sustainable development awareness in young people.

171 Following the ethics of data protection, identification of the interview participants is done  
172 using fictional names. In addition, all participants gave consent to be recorded and have their answers  
173 used as part of this academic research.

174

#### 175 2.4. The educational proposal

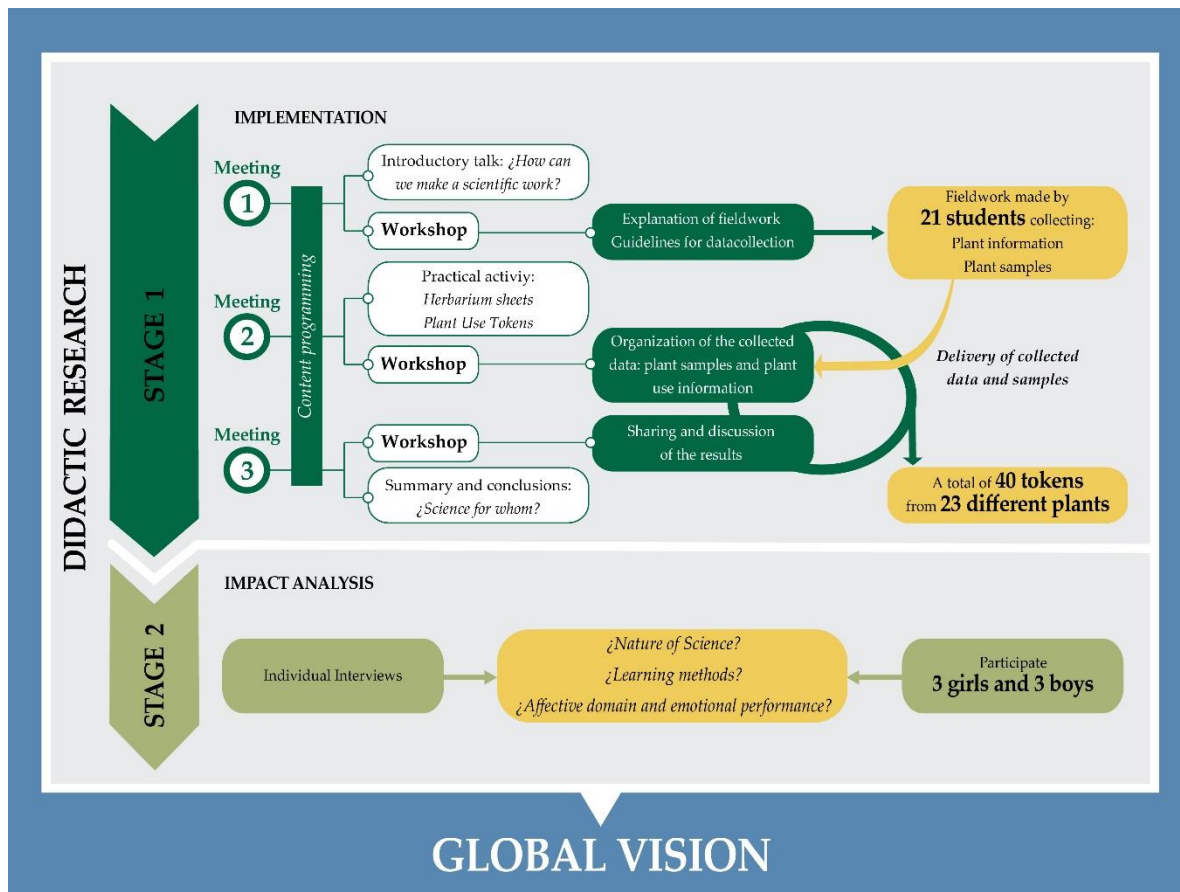
176 A pedagogical proposal was made consisting of a workshop based on the scientific method and  
177 research applied to Ethnobotany called "Learning to research in our protected space—Sierra Grande  
178 de Hornachos". This proposal was part of the program "The Week of Science and Technology in  
179 Extremadura", an oriented program focused on K-8 to K-12 students from public or private centers,  
180 which has been held annually since 2017 and whose main objective is to promote scientific culture  
181 and its dissemination.

182 The didactic proposal was divided into 3 milestones, carried out over 3 days and lasting 2 hours  
183 each, within school hours. The participation of the Center's director and faculty of teachers was  
184 necessary. Every day the workshop was attended by all the selected students accompanied by a  
185 group of teachers (ranging from 3 to 4 teachers) who depend on shift work or whose schedules were  
186 dedicated to the workshop.

187 The content focused on the significant interculturality that persists in knowledge linked to wild  
188 and cultivated plant species of enormous value [25].

189 The activities carried out are detailed below and summarized in Figure 2.

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Figure 2. Graphic summary of the study process.

Milestone 1. (first session) Introductory talk on the work carried out by scientific staff, the importance of the promotion of science, and the scientific method, an exhibition of workshop objectives and programming, an explanation of fieldwork or practical workshops, and the delivery of data collection sheets and guidelines to follow.

Milestone 2. (second session) Collection of tokens and samples by students and resolving any doubts; practical activity: preparation of herbarium sheets with vegetable samples of *Arbutus unedo* L., a typical plant in the study area.

Milestone 3 (third session) Sharing and discussion of the results obtained from the collection of data carried out by students, highlighting the most significant plant species, and discussion and conclusions of the sessions.

Below is the field activity or hands-on workshops conducted by students outside the classroom. These tasks consisted of each student choosing one or two adults over the age of 70 to be treated as an ethnobotanical informant. The selected persons could be family, but they had to be linked to rural life and should, therefore, know the traditional uses associated with wild or cultivated plant species. Students had to ask about the traditional uses that local wild or cultivated plants might have in this particular area.

A model table was used for data collection. Each student was given two tabs (Figures 3, 4) that served as a script and included informed consent informing them about the research and the purpose of the collection of the data, which all the interviewed adults signed. Each of these tables was identified with a different tab code, making it easy to identify later.

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**Remember:** you must interview a family member or acquaintance, over 70 years of age, with knowledge of plants in the field and collect the information that appears on this tab. If that person allows you to record it or take photos to the plant, save the documents indicating your first name, last name and the corresponding tab code.

**DATA FROM THE TAB**

Tab code: SMC1

Interview date:

**INTERVIEWER DATA**

First and last names:

Course: Age:

**PLANT DATA** Photography is included:  Yes  No

Common name (can have several, write them all):

Scientific name (we will fill it in later):

Is it a wild or cultivated plant?:  Wild  Cultivated

What parts of the plant is used? (check all necessary options):

Leaves (L)  Stems (St)  Roots (R)  Fruits (Fr)  Seeds (S)  Flowers (F)

What was it used or used for? (you can check all the necessary options):

L  St  R  Human food  L  St  R  Animal medicine  L  St  R  It is used to make tools and other utensils

Fr  S  F  Fr  S  F  Fr  S  F

L  St  R  Animal feed  L  St  R  It's toxic or poisonous  L  St  R  Used at traditional parties or events

Fr  S  F  Fr  S  F  Fr  S  F

L  St  R  Medicine for humans  L  St  R  As fuel  L  St  R  As an element of construction

Fr  S  F  Fr  S  F  Fr  S  F

L  St  R  Other use(s) (write which one):  L  St  R  Fr  S  F

**INTERVIEWED DATA** Informed consent:  Yes  No Audio/video included:  Yes  No

First and last name:

Age: Sex:  Man  Woman

Profession (what most of his life has been devoted to. Write only one):

Locality where he has lived most of his life and province:

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Figure 3. Data collection sheet provided to students (front).

**DETAILED USES OF THE PLANT (ELABORATIONS)**

Human food	As fuel
Animal feed	It is used to make tools and other utensils
Medicine for humans	Used at traditional parties or events
Animal medicine	As an element of construction
It's toxic or poisonous	Other use(s)

**WITNESS**

Common name (can have several, write them all):

Scientific name (we will fill it in later):

SAMPLE	PHOTOGRAPHY
Tab code:	Own photography
Place to collect:	Tab code:
Collection date:	Photograph of the book (A. Gabaldón)
	Page number on which it appears:

**INFORMED CONSENT**

I, \_\_\_\_\_ agree to participate voluntarily in this workshop, and I indicate that  Yes /  No I want to be recorded during the interview.

In Hornachos, to \_\_\_\_ November 2019.

Sgd.

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Figure 4. Data collection sheet provided to students (back).

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For the design of the data collection sheet, 10 subcategories of use were considered based on those described in the Spanish Inventory of Traditional Knowledge Relating to Biodiversity [34]. Each of these subcategories was quoted verbally during the workshops for each of the plants, while the interviewer (student) wrote the information given by the informants. These subcategories relate to the types of uses that a plant can have for humans. Each of them is detailed below:

1. Human food; 2. Animal feed; 3. Medicine for humans; 4. Animal medicine; 5. Toxic or poisonous; 6. Fuel; 7. Used to make tools and other utensils; 8. Used for traditional parties or events; 9. Used as a building element; 10. Other uses.

229 The time spent on each interview was variable and depended on the work done by each student.  
230 The tokens, samples, and photographs provided were collected by the researchers during the second  
231 day of the workshop, and the data were digitized at the Botany Laboratory of the University of  
232 Extremadura to be exhibited and, in the last session, debated in the classroom.

233

## 234 2.5. Data analysis

235 Both quantitative and qualitative mixed methodologies were considered [35]. In the analysis of  
236 the development of the workshop as well as the practical workshops carried out by the students, the  
237 quantitative logic was applied, while in the second part of this research, open interviews were  
238 conducted with a small group of student participants in the workshop whose results were  
239 qualitatively analysed to assess the educational impact of the proposed activity. In this last case, the  
240 individuals were selected according to what the teachers suggested when they were asked for  
241 students that could comply the following conditions: a) They attended the activity; b) they were not  
242 especially brilliant students or had a clear and evident motivation towards the sciences; and c) they  
243 came from the village and had the opportunity to connect with their own relatives in ethnobotanical  
244 research.

245 For the second part of this work, direct unstructured interviews were used to avoid limiting the  
246 interviewee's responses [36].

247 Six students, 3 boys and 3 girls, were selected. All students had participated in the face-to-face  
248 workshop and also showed interest and involvement in the practical workshops, delivering truthful  
249 information on two plant species collected in the tokens provided to them along with a sample and /  
250 or a photograph of those plants as a sample.

251 The interviews were conducted individually in the month of March 2020 during school hours  
252 during the time dedicated to recess. This period was four months after the activity itself took place,  
253 so the responses and the whole conversation can be considered a memory of the practical workshop.

254 To facilitate comfort and conversation, 6 open-type issues were designed for obtaining  
255 information on the impact of the conferences held in the first phase and determining their educational  
256 impact. These issue were the initial starting point for a fruitful conversation that was recorded and  
257 analyzed. Three fields of study or variables were thus established: 1. Learning about science, 2.  
258 Learning about botany, and 3. Emotional performance. Thus, the number of issues for each variable  
259 is 3. Over the course of the interviews, the interviewer used the pre-designed questions as a guide  
260 and was able to pose them in a different order or ask other secondary questions (but always keeping  
261 in mind the objectives).

262 The data were collected by using audio recordings and field notebook annotations. Two different  
263 experts analyzed each recording to identify the particular expressions for each variable. Afterwards,  
264 a third expert contrasted both codifications and made them reach a consensus for qualified data  
265 codification.

## 266 3. Results and Discussion

### 267 3.1. Quantitative data analysis: the workshop

268

269 Curiosity and motivation are essential for learning. This is determined not only by the teacher's  
270 performance or the subject matter but also by the teaching methodologies employed [37].  
271 Traditionally, methodologies have been promoted where the teacher is the protagonist and the  
272 student is a simple recipient; however, more active methodologies involve the participation and  
273 direct intervention of the student in concrete or everyday experiences, which allows greater  
274 activation of knowledge [38,39].

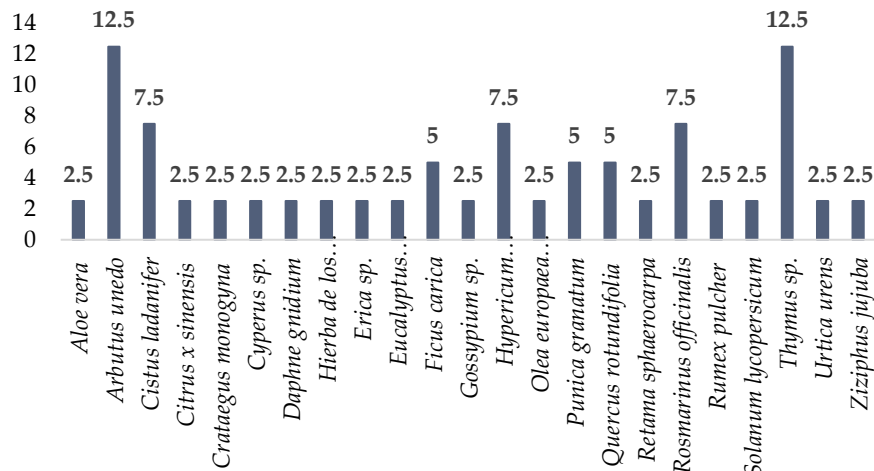
275 During the development of the present workshop, the direct involvement of the students in the  
276 practical activities was varied. On the first and third days, where the methodology used involved  
277 speaking or discourse, the performance of the students was more passive, showing an increase in  
278 interest when the analysis and discussion of the results obtained from the fieldwork was carried out,  
279 suggesting that this work was a topic of interest to the students; in the second part, all the students  
280 became involved, although this was not an optional decision.

281 Moreover, in the workshop that took place outside the classroom, motivation was an important  
282 factor. Several authors argue that the choice of the subject of study is essential to achieve greater  
283 learning [40]. Further, not all students attending the workshop participated in the practical  
284 workshops held outside the classroom because such workshops were not mandatory. More than 29%  
285 (nearly a third) of students conducted interviews with their elders and collected the information in  
286 the pieces previously provided to them. Thus, a total of 21 students collected a total of 40 tokens.  
287 Therefore, almost all students collected information from two plants. Specifically, 19 of them collected  
288 information from 2 plant species, among which 4 also delivered plant photographs and samples, and  
289 2 contributed a sheet with 1 species per person, one of which was accompanied by a photograph and  
290 vegetable sample.

291 Information was collected from 23 different plants—9 cultivated (*Aloe vera* (L.) Burm. F., *Citrus*  
292 *x sinensis* (L.) Osbeck, *Ficus carica* L., *Gossypium* sp., *Olea europaea* subsp *europaea* var. *sylvestris* (Mill.)  
293 Lehr., *Punica granatum* L., *Rosmarinus officinalis* L., *Solanum lycopersicum* L., and *Ziziphus jujuba* Mill.)  
294 and 14 wild plants (*Arbutus unedo* L., *Cistus ladanifer* L. *Crataegus monogyna* Jacq., *Cyperus* sp., *Daphne*  
295 *gnidium* L., *Erica* sp., *Eucalyptus camaldulensis* Dehnh., *Heliotropium europaeum* L., *Hypericum perforatum*  
296 L., *Quercus rotundifolia* Lam., *Retama sphaerocarpa* (L.) Boiss., *Rumex pulcher* L., *Thymus* sp., and *Urtica*  
297 *urens* L.), some of which appeared more frequently than others (Figure 5). Among the most  
298 represented were *Arbutus unedo* and *Thymus* sp., indicating that these species are of great interest to  
299 the ethnobotanical identity of Sierra Grande.

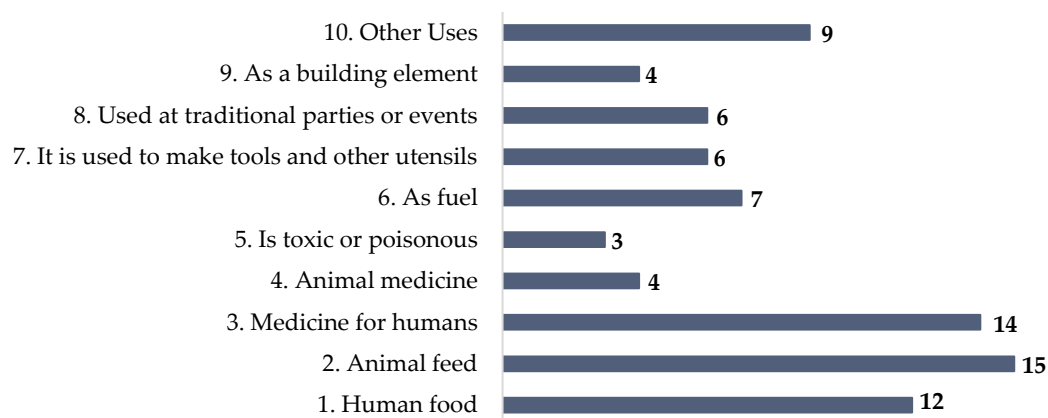
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302  
303 **Figure 5.** Frequency with which each species appeared in the collected tokens.  
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305 A total of 80 uses were obtained, the majority of which were: 2. Animal feed, 3. Medicine  
306 for humans, and 1. Human food (Figure 6). The maximum number of uses obtained for the same  
307 species was 8, and this figure was only achieved for *Arbutus unedo*, followed by *Thymus sp.* with  
308 7 and *Crataegus monogyna* with 6. From the set of extracted information, we also observed that  
309 the most commonly used parts of the plant were the Leaves (L) and Stems (St), which were  
310 consumed from more than 13 of the 23 total plants. Least used were the Seeds (S), which were  
311 only used for three species (*Ficus carica*, *Retama sphaerocarpa*, and *Urtica urens*). Flowers (F) and  
312 Fruits (Fr) were also used for more than 40% of species (Appendix A1).  
313



314 **Figure 6.** Total uses obtained by subcategory.  
315

316 The Autonomous Community of Extremadura is one of the Spanish regions with the fewest  
317 ethnobotanical studies [41]. Most studies focus on medicinal and veterinary plants [42,43,52,44–51].  
318 However, few enclaves in the region have had in-depth studies on the traditional knowledge that  
319 communities possess about their plants. Two exceptions are the Monfragüe National Park, in the  
320 province of Cáceres [53], and Calabria and Siberia in Badajoz province [54]. For the Regional Zone of  
321 Interest (RZI), Sierra Grande de Hornachos, only one recent study has been done on edible plants  
322 [55]. Therefore, the results obtained by the students, which may seem modest, have high scientific

323 interest since most of the uses collected are novel for the area and, in some cases, are novel for the  
324 region.

325 The results reveal that the students who participated did so with total involvement. In general,  
326 the group proved to be curious and interested in the plants and cultural richness of their environment,  
327 which is a very interesting source of knowledge.

328

### 329 3.2. Qualitative data analysis: the interviews

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331 Analysis of the six interviews offered interesting insights into the three study fields: nature of  
332 science, learning methods, and affective domain and emotional performance. Since a qualitative  
333 methodology was used, the most relevant results were obtained by examining samples from the  
334 recorded interviews. The entire text for these interviews is available upon request. The following  
335 section offers samples from the interviews.

336

#### 337 3.2.1. About Nature of Science (NOS)

338 These interviews included several specific questions on how the students understand some of  
339 the core concepts of the nature of science, such as: What do you think science is? What is Science for?  
340 What do you know about the Scientific Method? and What is a scientist for you? Students had  
341 difficulties defining these concepts, which agrees with previous studies [56], but some  
342 understandings were clear:

343

344 "Science is important for society" (Individual 1)

345 "Science is knowledge, and there are many kinds of scientists" (Individual 3)

346 "Science explains reality" (Individual 3)

347

348 These students presented epistemologic statements about the focus of science and how it influences  
349 their lives. Furthermore, when asked about scientists and the scientific method, they said:

350

351 "Science method is a pathway, a procedure for researching." (Individual 2)

352 "A scientist has to have interest in details and be rigorous, careful... Science cannot be made  
353 with fuzzy borders." (Individual 3)

354 "A scientist cannot be subjective, but objective." (Individual 4)

355

356 The interviewees easily identified some of the most relevant values of science in itself [57], such as  
357 objectivity, reliability, methods, and systematicity.

358

#### 359 3.2.2. About the botanical learning method

360 An important insight of the current work is to determine how important the method is that we use  
361 to teach science, particularly botanical science. In this sense, the students again expressed ideas that  
362 were different from traditional ways of learning:

363

364 "I like plants. What I liked the most was the practical activity with the strawberry tree."  
365 (Individual 2)

366 "(making things directly by hand) is a very motivating way of learning. I felt ready to make new  
367 things and to learn. " (Individual 3)

368 “Question: Is it easier to learn in this way? Answer: Yes, yes, much better. This is better than  
369 writing all the time.” (Individual 5)

370 “The most boring part was the initial oral exposition.” (Individual 6)

371

372 3.3.3. About sustainability as an integral concept involving ethnobotanical ideas

373

374 Cultural sustainability is not a very frequently taught subject when discussing sustainability  
375 concepts. Indeed, the relevance of cultural sustainability was only recently framed [11]; presently, it  
376 is not possible to talk about sustainability without mentioning cultural sustainability. In this sense,  
377 the interviews exhibited the acquisition of several interesting ideas:

378

379 “Question: Do you think it is important to preserve these uses for these plants (traditional  
380 medicine usages)? Answer: Yes, so in the future we will be able to know how the past was.”  
381 (Individual 1)

382 “I have learned some new information about plants and how to keep in contact with nature.”  
383 (Individual 4)

384 “I have learned general culture about the plants that are around us in our town. We should be  
385 proud of living in such a beautiful place, with a lot of plants with interesting usages. This is part of  
386 our town and its history.” (Individual 5)

387

388 3.3.4. Feelings, self-regulation, and emotional performance of the learning process

389

390 Lastly, the core dimensions of education, such as self-regulation of the learning process, and several  
391 emotional aspects emerged during the interviews, as can be seen in the following statements:

392

393 “The practical workshop helped me learn more vegetal species. I already knew some of them,  
394 but now I can identify more.” (Individual 1)

395 “I felt happy; nothing made me feel bored.” (Individual 2)

396 “I would recommend using these kinds of activities again during the course.” (Individual 6)

397

398 Qualitative analysis of the interviews revealed effectiveness in the acquisition of many types of  
399 knowledge, not only knowledge related to botanical learning but also the understanding of  
400 ethnobotanical issues, the value of cultural sustainability, and even an understanding of various  
401 aspects related to the nature of science. In addition, since these interviews were carried out several  
402 months after the activity, they revealed a significant recall of related knowledge.

403

#### 404 4. Conclusions

405 Considering the results obtained, we conclude that the use of training techniques and tools based  
406 on active methodologies provides an interesting resource to generate knowledge in symbiosis with  
407 traditional classroom teaching (i.e., for ethnobotany in the "Sierra Grande" protected area of  
408 Hornachos).

409 This work has shown that a non-formal activity inserted into a standard academic space (a high  
410 school) has a positive impact on the acquisition of botanical and ethnobotanical knowledge.  
411 Moreover, if designed according to an integral sustainability vision framework, student can develop  
412 positive attitudes towards traditional knowledge preservation. Further, if designed with close

413 collaboration between secondary teachers and university researchers, this type of activity can  
414 promote the core concepts of the Nature of Science, such as what science is for, and what kind of  
415 person a scientist is.

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418 draft preparation, L.G.-G. and T.,R.-T.; writing—review and editing, J., B-S.; visualization, L., G-G.; supervision,  
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421

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426

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<i>Gossypium</i> sp.	Planta de algodón	1	C	Fr					
<i>Hypericum perforatum</i>	Árnica	3	S	L, St, F					
<i>Olea europaea</i> subsp. <i>europaea</i> var. <i>sylvestris</i>	Olivo	1	C	L, Fr					
<i>Punica granatum</i>	Granado	2	C	L, St, R, Fr					
<i>Quercus rotundifolia</i>	Encina	2	S	St, Fr					
<i>Retama sphaerocarpa</i>	Retama	1	S	L, St, Fr, S, F					
<i>Rosmarinus officinalis</i>	Romero	3	C	L, F					
<i>Rumex pulcher</i>	Romaza	1	S	L, St, R					
<i>Solanum lycopersicum</i>	Tomatera	1	C	Fr					
<i>Thymus</i> sp.	Tomillo	5	S	L, St, R, F					
<i>Urtica urens</i>	Ortiga	1	S	L, S					
<i>Ziziphus jujuba</i>	Azufaifa	1	C	L, St, Fr					

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