

A tool for the development of competencies in sustainability and carbon footprint reduction in schools.

I.Marques-Valderrama^a, R.Chacartegui^b, J. A Becerra^c, Yolanda Lechón Pérez^d, Antonio José Serrano Jiménez^e, Susana Marta López Almeida^f and Carmen Díaz López^g

^a University of Seville, Seville, Spain, imarques2@us.es

^b University of Seville, Seville, Spain, ricardoch@us.es

^c University of Seville, Seville, Spain, jabv@us.es

^d CIEMAT, Madrid, Spain, yolanda.lechon@ciemat.es

^e University of Granada, Granada, Spain, serranojimenez@ugr.es

^f Instituto Superior Tecnico, Lisbon, Portugal, smarta@ctn.tecnico.ulisboa.pt

^g University of Seville, Seville, Spain, cdiazl@us.es

Abstract:

This work presents a tool for developing competencies in sustainability, focusing on evaluating the environmental impact and carbon footprint in schools. The tool is based on sustainability indicators and follows a methodology derived from the ClimAct and ECF4CLIM projects. It is conceived as a support for the users and the schools to identify and evaluate the relative impact of different actions and measures, to engage them in a sustainable pathway to low-carbon schools supporting their decision-making at the different levels of users. The areas are transport, waste, green procurement, green spaces, energy, water, and indoor air quality. The tool aims to support users and schools in identifying and evaluating the impact of various actions and measures, facilitating decision-making for a sustainable and low-carbon school environment. To quantify sustainability performance, Key Performance Indicators (KPIs) have been established for each area. The results from schools that tested the tool revealed low scores in green procurement (0.59/5) and water (2.03/5), while achieving higher scores in green spaces (3.46/5) and indoor air quality (3.92/5). These findings highlight the areas where improvement is needed and provide a basis for targeted interventions. Developed on the PowerApps platform, supported by Microsoft, the tool allows access to users of different ages and knowledge levels. It has been successfully tested in six schools in Andalusia, Spain, obtaining relevant results in the seven sustainable areas defined. Based on the results, this tool will be used within co-creation and co-implementation processes for more sustainable schools and competencies acquisition by the participants.

Keywords:

Methodology; Sustainability; Carbon footprint; low-carbon schools; KPI; PowerApps

1. Introduction

Innovation in sustainable education is a critical issue to consider for the formation of present and future generations. Developing tools that facilitate acquiring sustainable skills is fundamental to achieving these objectives. The development and promotion of sustainability education have become one of the key challenges to be addressed within European society, especially in the wake of the Paris Agreement [1], which recurrently calls for a society that lives and works in a sustainable way. The measures and policies were developed to enhance society's development to promote a low-carbon economy. To this end, programs have been developed ranging from the countries involved in the agreement to measures that affect the entire European community. The incentivization of programs that allow society to develop sustainably is a priority to achieve the objectives set out in the Paris Agreement. Programs such as Horizon 2020, promoted by the European Union [2], have encouraged the promotion of activities that favor sustainable development, seeking to strengthen the relationship between science and society by encouraging, among other things, the participation of civil society [3].

Considering the importance of developing sustainability competencies, the value of education as a fundamental tool to achieve the proposed objectives is emphasized. Developing sustainability competencies

in schools is one of the main ways to promote a low-carbon society. Considering that, in areas such as southern European Mediterranean countries, more than half of the buildings used for school use predate 1990 [4], and taking into account the social situation surrounding schools, there are opportunities to design strategies to trigger action in schools. In order to assess the adequacy of knowledge and skills transfer to schools, it is necessary to design indicators through which sustainability parameters can be determined [5]. To this end, within the framework explained above, projects such as ClimAct [5] have been developed, where a methodology has been implemented for the development of sustainability competencies that have been evaluated by measuring a series of indicators, applied in different schools in Spain, Portugal, France, and Gibraltar. The application of a methodology for monitoring and ensuring adequate knowledge acquisition and monitoring progress through indicators is a key tool for developing sustainability competencies in educational communities [6].

Taking into account the need to apply methodologies in schools to create a sustainable society, and taking advantage of the impetus offered by European projects such as ECF4CLIM - A European Competence Framework for a Low Carbon Economy and Sustainability Through Education, the use of computer applications was proposed with the aim of facilitating the transmission of knowledge and the application of methodologies to support sustainability, which is capable of providing support and content at all possible educational levels, from the beginning of the educational process to the higher stages [7]. The use of platforms developed by Microsoft for the development of multi-platform applications makes it possible to create tools that meet the proposed needs [8]. Combining the determination of performance indicators as well as the use of these results as support material for education, a tool has been designed within the PowerApps environment from Microsoft [9]. The purpose of the application developed is to allow the centres to self-audit their sustainability level and opportunities for improving it within their circumstances. The goal of this work it's to develop and validate a tool for improving the competences in sustainability in schools, reducing at the same time the carbon footprint due to the institution diary activity, using for this purpose, a testing process executed in six andalusian schools. The application is conceived to be used at all educational levels with different access levels. The tool allows for assessing the impact of the different actions. Combining the use of the methodology and the creation of the platform developed, we bring to schools a novel tool for identifying and developing sustainable competencies in students, supported by a friendly interface. As a consequence, the co-creation and co-implementation by the students, teachers and managers are expected to allow the acquisition of individual and global competencies in sustainability during the process. [6] The structure of the paper is the following. First, the methodology for sustainability skills acquisition is described. Then the structure of the tools is presented. Follows the application case to 7 seven schools in Andalusia. Finally, the main results of the application case and discussion are presented.

2. Methodology

The tool covers a wide range of sustainability aspects divided into seven areas. KPI behaviour indicators are defined for each area based on the specific school data (such as, for example, the number of students or area covered). These areas are [6]: *Transport, Energy, Water, Garbage, Indoor Air Quality (IAQ), Green Spaces and Green Supply*. The KPIs values provide a quantitative evaluation of different sustainability branches related to the school. It allows the analysis of discussion about the potential actions for improving them, if possible, and their implications. The methodology looks for analysis and debate about the sustainability areas to be improved and the evaluation and proposal of specific actions. The KPIs quantify the impact and provide a reference for assessing the departing point and evolution and the situation compared with other schools to identify the real range of the indicators and their adjustment. Once a roadmap with specific measures is defined, the centres will apply the appropriate actions. After their implementation, the results of the indicators will be reviewed again, being able to identify changes. Throughout this process, all the participants will develop sustainability skills. In addition to skills in sustainability, skills will be developed and acquired around the realisation of small-scale projects, which will allow for marking the objectives of the measure and identifying necessary resources.

2.1. ECF4CLIM Sustainability indicators

Behavioural indicators (KPIs) as support for decision-making is a common practice that aims to carry out actions more efficiently or sustainably. The study carried out and modelled in the PowerApps application is based on sustainability indicators whose concept was defined within the ClimAct project [5]. In total, 27 scores were defined, evaluating aspects related to 7 areas of sustainability. The areas of sustainability for this project are Water, Energy, Transport, Green Procurement, Green Areas, Garbage, and Indoor Air Quality. 34 KPIs distributed in the aforementioned sustainability areas were defined to calculate the scores. Table 2 breaks down the definition of the indicators used. Their calculation provides a normalised score in the range between 0 and 5.

2.2. Development of sustainability competencies

A five-step methodology has been developed to acquire capacities in sustainability by the educational community effectively. Sustainability indicators support the process, providing quantitative values for assessing the impact of the different steps and to guide the participants. For the correct execution of the steps, different groups of students will work as a team, carry out the audits, propose and implement measures, evaluate the departing and final situations, and evaluate the impact of the actions. The steps for the application of the methodology are as follows:

1. Determination of the initial situation: The methodology starts with evaluating the departing situation through auditing the centre based on the defined sustainability areas. Templates and forms are provided to guide the data collection process, providing an explanation of the different aspects related to the data collected. Different working groups will focus on specific areas collaborating to cover the whole set.
2. Evaluation of the initial situation: Audit results are analysed and evaluated by the groups, either jointly or separately, identifying those aspects in which the school has the potential to improve. The working groups validate the results and discuss the improvement capacity in relation to the current situation of the school.
3. Co-design of measures to improve sustainability: After completing previous steps 1 and 2, the working groups interact with the rest of the scholar community (students, teachers, administrative) to generate a list of possible measures to implement in the centre. From that list, measures are proposed and selected. The working group develops a specific implementation project for each action, defining the activities, schedule, milestones, resources and expected impacts. The selection includes the evaluation of their feasibility by the management of the centre.
4. Co-implementation of approved measures: The working groups execute the selected projects. Tasks are distributed as a function of the educational level of the participants with external support.
5. Determination of the impact of the measures implemented: The impact of the implemented measure is evaluated. In this phase, the cycle will be closed, returning to the initial phase through the completion of the audit.

The implementation of the methodology promotes the acquisition of competencies in sustainability by the students and staff participating. They evaluate, measure, analyse, discuss, propose and execute different aspects of sustainability in the centre. It generates individual and collective competencies in each stage.

3.3 Key Performance Indicators

The impact of the measures through the analyses is identified using indicators to take decisions. The Sustainability Key Performance Indicators used are defined in the table shown below:

Table 1. Definition of KPIs used.

Sustainable area	Environmental pillars	Key Performance Indicators
Transport	Car park	KPI-T1. No. of parking spaces for electric cars at school or periphery per student (up to a 100m radius)
Transport	Car park	KPI-T2. No. of parking spaces for bicycles at school or periphery per student (up to a 100m radius)
Transport	Public transport network	KPI-T3. No. of public transports passing daily per hour (1000 m radius)
Transport	CO2 emissions	KPI-T4. Annual CO2 Emissions per student (kgCO2/student)
Green procurement	Equipment efficiency	KPI-GP1. No. of equipment A+ or higher EU Energy Label per total no. of equipment
Green procurement	Paper usage	KPI-GP2. Annual paper usage in school per student (kg/student)
Green procurement	Paper usage	KPI-GP3. Recycled paper usage in school (kg recycled /kg consumed)
Green procurement	Training in green procurement	KPI-GP4. No. of staff with training in green procurement per total no. of staff
Green procurement	Organic food	KPI-GP6. Food with biological certificate (kg food with biological certificate/kg total food)
Green procurement	Suppliers	KPI-GP7. Local suppliers (No. local suppliers /total suppliers)
Green spaces	Green areas	KPI-GS1. Number of trees per non-covered area (m2)
Green spaces	Green areas	KPI-GS2. Number of trees per student (student1)
Green spaces	Green areas	KPI-GS3. Green area per non-covered area (%)
Green spaces	Green areas	KPI-GS4. Green area per student (m2/ student1)

Green spaces	CO2 sequestration	KPI-GS5. Annual CO 2 sank per non-covered area (kgCO 2/m2)
Green spaces	Use of chemicals	KPI-GS6. Total kg of chemicals used for green area maintenance (kg/m2)
Green spaces	CO2 emissions in maintenance	KPI-GS7. Annual CO 2 emissions for the space maintenance of non-covered area (kgCO 2/year.m2))
Energy	Energy consumption	KPI-E1. Annual final energy consumption per area (kWh/m2)
Energy	Energy consumption	KPI-E2. Annual final energy consumption per student (kWh/student)
Energy	Use of renewable energy	KPI-E3. Renewable energy production (%)
Energy	Energy cost	KPI-E4. Annual energy cost per m 2 (€/m2)
Energy	Energy cost	KPI-E5. Annual energy cost per student (€/student)
Energy	CO2 emissions	KPI-E6. Annual carbon footprint per student (kgCO2/student)
Water	Water consumption	KPI-H2O1. Water consumption (m3/m2)
Water	Water consumption	KPI-H2O2. Water consumption (m3/student)
Water	Water cost	KPI-H2O3. Water cost (€/m2)
Water	Water cost	KPI-H2O4. Water cost (€/student)
Waste	Waste produced	KPI-W1. Volume of waste produced (non-recyclables and reusables (m3/student)
Waste	Waste recycled	KPI-W2. Volume of waste recycled (m3/student)
Waste	Waste reused	KPI-W3. Volume of waste reused (m3/student)

The combination of each indicator in each sustainable area, gives a result between 0 and 5. A tool for their evaluation, analyses and discussion has been developed to support the process [5]. Main characteristics are described in the next section.

3. Sustainability KPIs Tool

This section describes the tool developed to support the methodology in the schools.

3.1. Platform description

The tool has been developed based on the combination of two Microsoft solutions, PowerApps and Power Automate[10], tools designed to support the creation of applications. Both applications were framed in an environment created in Azure [11], where user management and license assignment were carried out [12]. On the other hand, database management was carried out for the calculations of indicators and monitoring of the studies from the SharePoint platform [13]. The interaction within the platform is described in the scheme of Figure 1:

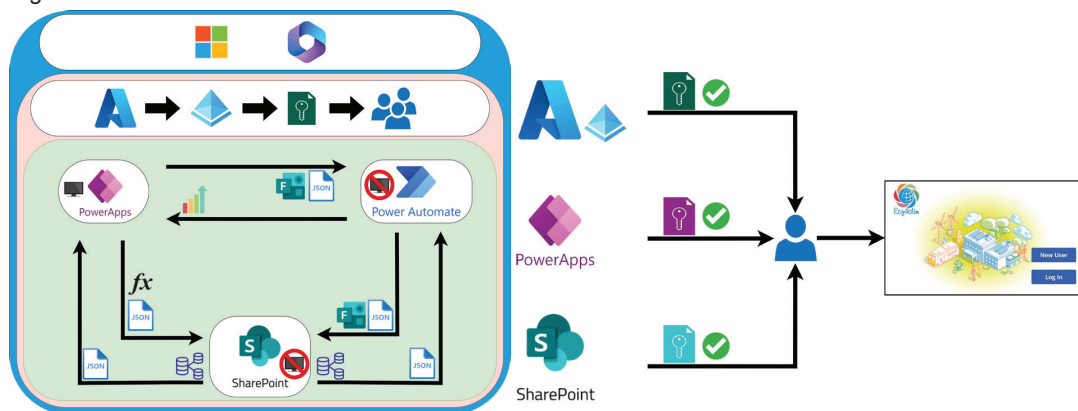


Figure 1.- Application situation diagram.

The use of Azure allowed the management of users, licenses and permissions. Different access levels are provided as function of the user's profile. From the user's point of view, authentication is done with the Microsoft user [14], which contains all the requirements that are requested for access.

3.2 Sustainability areas

For each of the seven sustainability areas, the application works independently. Their specific information is introduced into the study gradually. The data submenus include the possibility to edit or delete the information

entered. School's codes are used to define common characteristics for different studies or users(i.e. buildings parameters). Data introduction and navigation process are explained in the next schema:

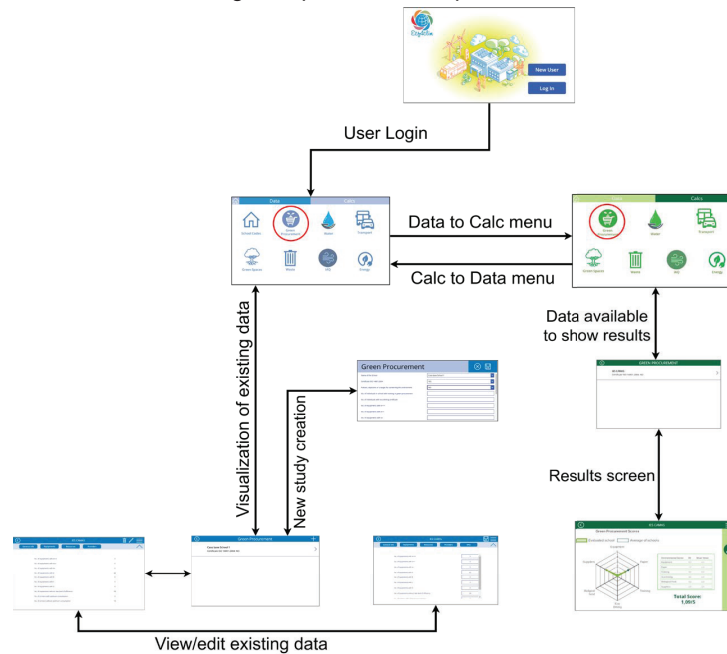


Figure 2. Navigation scheme of the application.

The application is divided between the data collection part and the sample of results through colours (Blue – data menu; Green – calculations menu). The operation of the application is the same in all areas of sustainability. After login into the application, school study cases are available. The Data menu, blue theme, shows the data introduction menus for the sustainability area to study. For the chosen sustainability area there is a gallery with the created studies (if there are any). New studies are created by pressing the "+" button at the top right of the screen. Existing ones can be viewed/edited by selecting them.

The calculation menu (green theme), where the user, after creating a case in the data section, can represent the results of the sustainability indicators on a radar graph [15]. The application calculates the sustainability indicators based on the existing studies in the databases, allowing the creation of global studies and comparisons. Results are displayed in graphical and numerical form.

3.3.1. Display of scores

The general structure for visualising results is based on radar graphs representing the scores on the indicators related to the sustainability area studied, figure X:

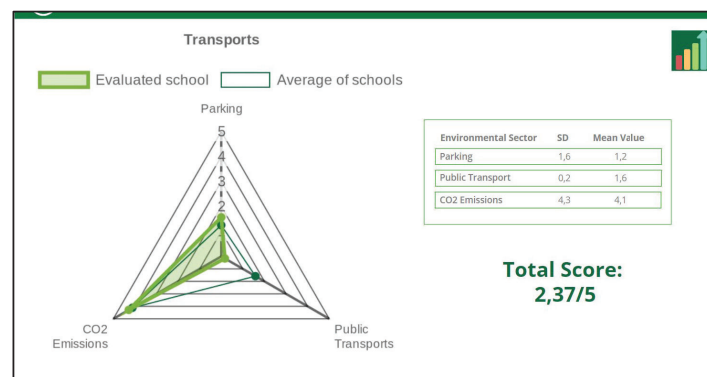


Figure 3. Example of visualisation of results in the application.

4. Example of real application of the tool in schools

The objective of the application is to support schools in using the methodology for the acquisition of competencies. The application is being launched to the schools involved in the ECF4CLIM project, where the methodology will be implemented and assessed.

4.1 Youth with researchers pilot experience

The tool was tested in a pilot experience in 6 educational centres in Seville, Córdoba and Malaga (Spain). The context has been taken as the realisation of the 8th congress of the Youth with Researchers program convened by different organisations such as CSIC, SADC or US [16]. In this activity, 25 students from different centres interacted with University researchers during four seasons, developing research projects in four different groups related to different sustainability areas and applying the tool to different centres. The purpose was double, to identify the perception of the students about the tool, receiving their feedback, and to evaluate its adequateness to the methodology. The projects were:

1. Sustainable mobility in schools. Education, evaluation and proposals.
2. Zero Waste Life. Towards a future in harmony with our planet.
3. Air quality and renewable systems at school.
4. Do we improve our yard? Bioclimatic strategies and environmental education applied in schoolyards.

During the work sessions, students and teachers were guided in using the tool to support the analysis and discussion about measures that improve the sustainable behaviour of the educational community, covering with their activity the first three phases of methodology. The distribution of the participants in the activity are preseted in the next table.

Table 2. Schools participating in the JCI 2023 project.

School Name	Location	Type of school	Nº of students involved in the project
School 1	Tomares, Seville	Secondary and High School	8
School 2	Camas, Seville	Secondary and High School	2
School 3	Camas, Seville	Secondary and High School	6
School 4	Montequinto, Seville	Secondary and High School	4
School 5	Ronda, Malaga	Secondary and High School	1
School 6	Córdoba	Secondary and High School	4

4.2 Results of the use of tool

After the audit work carried out by the JCI project students, the students determined those aspects in each center in which they obtained a lower score. Based on this result, they proposed sustainability measures, which, in some cases, have begun to be implemented in the centre. During the four sessions developed in the Youth with Researchers program, the students have been able to handle the tool, from which they detected possible ways of improvement in the centre. They were able to propose projects to increase sustainability skills in certain aspects of the centres involved. The developed application was used for all centres in the seven areas of sustainability. Below are the results obtained for the IES Ítaca school as an example of the activity carried out.

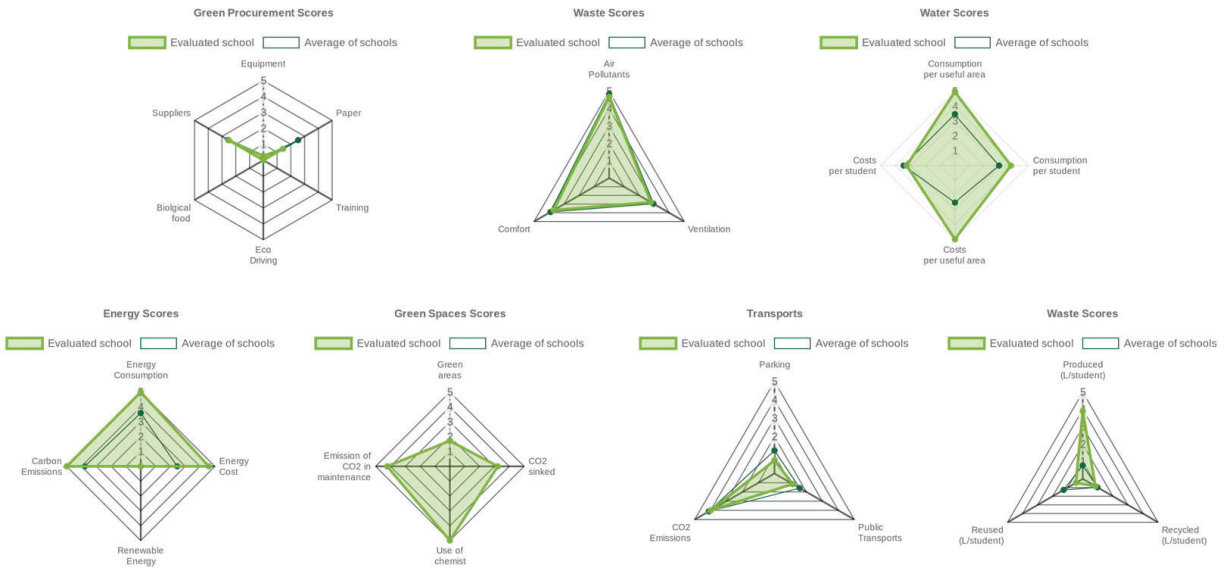


Figure 4. Audit results for School1.

The students used the graphs of the different schools to discuss and obtain conclusions. First, they were able to interpret what information in the study had greater or lesser validity depending on the characteristics of the school. On the other hand, in areas such as Transport and garbage, students understood that there were sectors in which they could apply improvements. It was also detected that the use of the application in the specific area of garbage was not as expected since the students did not correctly understand the operation of this area of sustainability. Finally, the students who were working on the application could not have enough information concerning the generation of renewable energy in the centres, so they did not add that type of information to the study. However, in the case of School 1, they do have a photovoltaic installation in the school. Below is a graph summarising the results obtained in all centres by sustainability area.

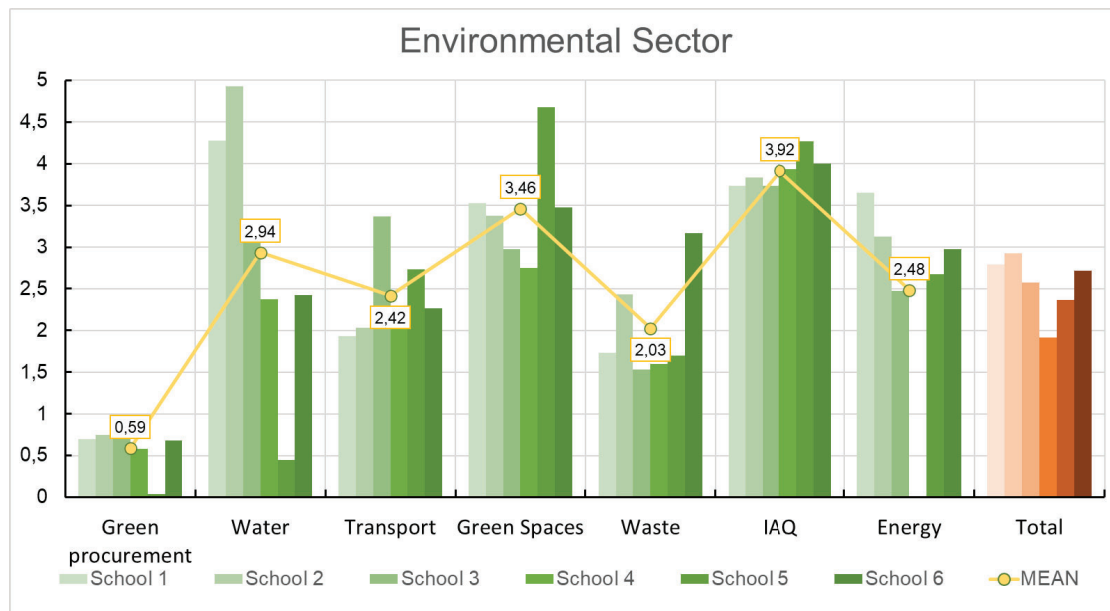


Figure 5. Global results obtained in the centres by sustainability area.

The graph shows for each centre the overall score that summarises the 34 KPIs and the 27 scores in the 7 areas of sustainability measurable in the application. From this graph, it is possible to determine the collective and specific behaviours of the educational centres studied. In the representation of the results, the centres are sorted by colours, as shown on the labels at the bottom of the graph. On the other hand, the means of the results have been represented together with the value of said result for all the centres studied, as well as the total score of each centre. Next, characteristics related to the origin of the data or the value that the students have provided through the work with the tool will be analyzed, so that, next, considerations made in each area of sustainability will be exposed.

4.2.1. Indoor Air Quality

First, the performance in relation to Indoor Air Quality in the classrooms where the students worked was similar, considering that the measurements focused on determining CO₂ concentration and temperature. In the schools 1 and 5, data on the concentration of different particles were available, thanks to previous measurements that were made through the ClimAct project, so these were added to the tool.

4.2.2. Waste

On the other hand, there were centers where it was understood that the information related to the garbage section was not introduced as expected, since inconsistencies were detected in the results. The approach of this area of sustainability assumes that the amount of waste recycled and reused will always be less than or equal to that produced according to the case. This fact was not correctly interpreted by all the students who used the tool, although in the follow-up sessions where the application was used, the results were discussed taking into account this fact. In centers such as IES Ithaca, there is a garbage management system through which they were able to evaluate this area of sustainability.



Figure. 6. Separation of garbage inside the IES ITACA center.

The image shown corresponds to one of the corridors of the school, where there are differentiated bins to carry out the correct separation of garbage. In addition, as transmitted by teachers and students, the same separation system is carried out inside the classrooms, so that students could make measurements based on the information they took from their own waste management system.

4.2.3. Transport

For this area of sustainability, a series of activities were carried out that served the students, among other things, to raise awareness about the CO₂ emissions that are undertaken by the simple fact of traveling to school. The access routes to the centers were also studied, as well as the availability of parking in the vicinity of the school. On the other hand, based on the results obtained, the students were able to discuss the transport network available in each case to access the school.

Among the activities carried out in this area of sustainability, a survey was carried out that was introduced in the application, where each student could answer questions about the transport method used to access the

school, as well as behavioral issues related to this topic. The survey was shared with the students of the study schools to increase the data sample as much as possible, with the aim of characterizing the general behavior of the students in each school.

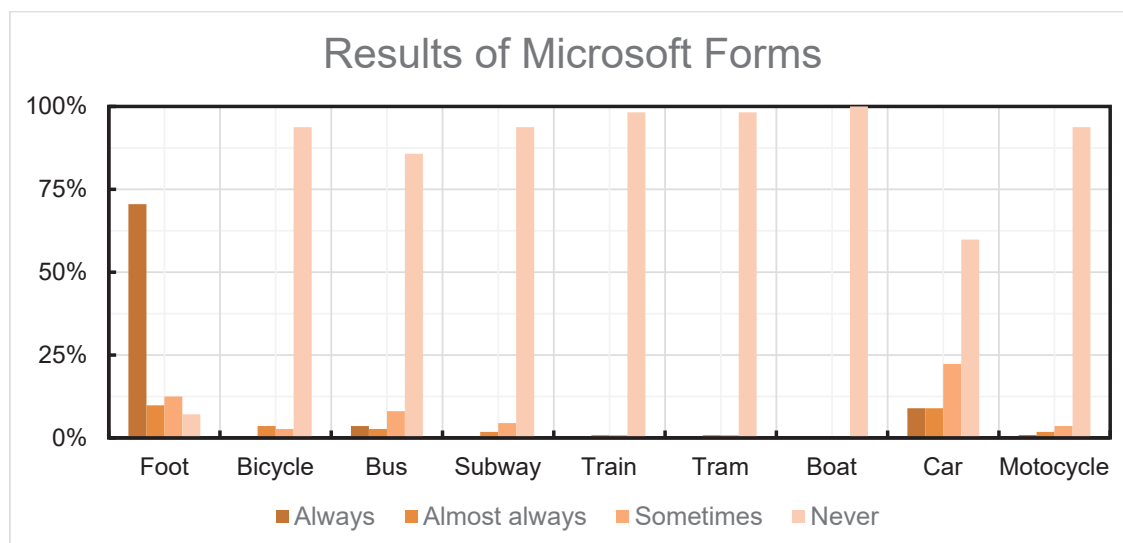


Figure 7. Results of the user behavior survey launched through Microsoft Forms.

On the other hand, some notions related to the management of Google Earth and Google My Maps were taught with the aim that students could determine the position of the public network within a radius of 100m, 500m and 1000m. From the maps generated, they were able to determine the number of bus, train and metro stations among others, as well as the determination of the number of parking spaces at different distances from the school.

4.2.4. Water

For this area of sustainability, the students relied on the data available in the IES Itaca and IES Martín Rivero centers in relation to the prices paid for consumption for the determination of their expenses, based on the consumption data they were able to obtain.

4.2.5. Energy

Within the development that the students made of the tool for this area of sustainability, they did not consider the part of the study dedicated to generation due to renewable facilities, although there are centers that do have a photovoltaic installation, as is the case of the IES Itaca mentioned above.

4.2.6. Green Spaces

To answer the questions posed in the study of green spaces, students had to perform tasks related to tree counting or determining the dominant species. Because they were unable to obtain information about the use of chemicals for maintenance, they did not answer those questions. That is why in the grade entitled "Use of Chemist" all schools obtained a score of 5, although the students debated about the subject, being aware that this result had no validity. For the determination of the dominant tree species in the school, the students made use of the Google Lens tool, through which they could determine the scientific name, which they then selected in the application. Finally, the determination of the score related to "Green Spaces" was obtained from the work done in determining the different types of surface that each school has.

4.2.7. Green Procurement

Finally, for the sustainability area of green procurement, students focused their studies on questions related to suppliers, paper management and the energy level of equipment. The questions of the remaining three tags remained unanswered, so, in these specific cases, unlike what happened in Green Spaces, scores of 0 were obtained. It took into account, among other issues, that the centers do not have a dining room, so obtaining a result of 0 in "Biological food" did not imply the proposal of any improvement by the students.

4.3 Discussion of results obtained

The purpose of the students in relation to the use of the tool, was to be able to detect aspects from which to propose measures to support the sustainability of the center, while developing the common project for the JCI contest. After using the tool, and discussing the usefulness and validity of the results in a working session, those aspects in the areas of sustainability that needed a measurement proposal were chosen. For this, all the results obtained in the 6 centers were considered, reasoning the considerations made previously.

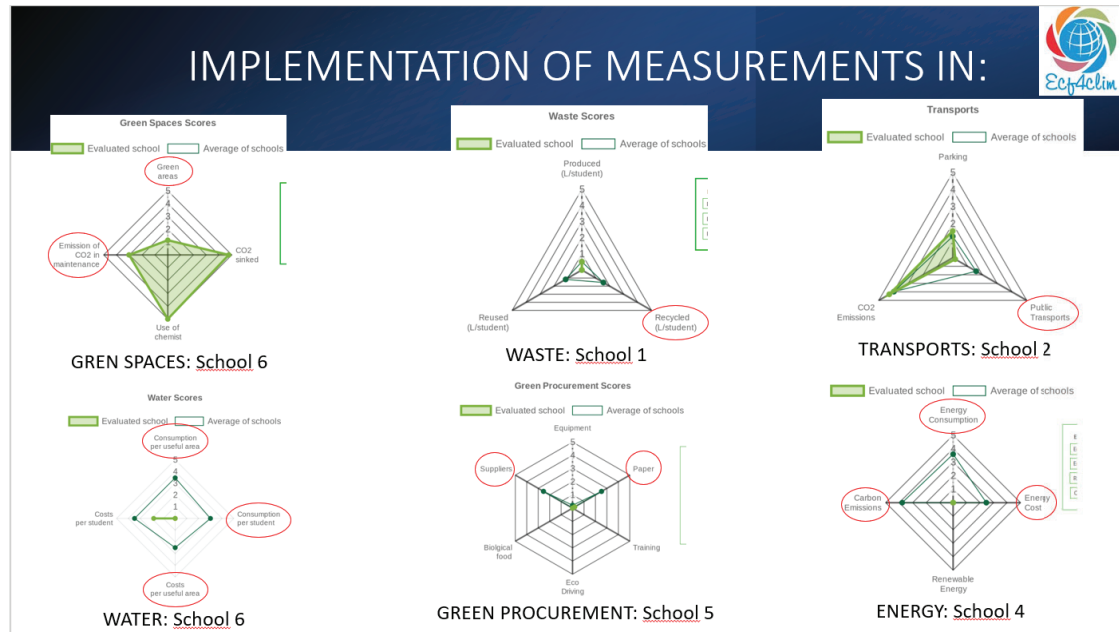


Figure 8. Sectors in the different areas of sustainability in which to propose measures.

Making a summary of the process explained to obtain these results, the students audited their centres, entered the data in the application, and then compared the results obtained in the different centres. Once this task was performed, those centres in which the score was markedly different from the average were identified. Students noticed that, in certain respects, schools did not behave appropriately regarding sustainability. They also knew how to correctly interpret the results obtained since they understood that obtaining a low score in a specific indicator did not indicate a lack of sustainability skills or carrying out poor behaviour. Within the results obtained, they made an extraction of the graphs in which it was detected that the performance was not adequate. Based on the results obtained, improvement measures were proposed in the centres for which these scores had been detected.

5. Conclusions

Developing solutions that facilitate the development of sustainability skills in schools facilitates the learning-by-doing process that should be carried out by the schools involved in the ECF4CLIM project. This paper shows the tool developed to support the analysis and discussion of sustainability-related actions in schools. It guides and simplifies the process of collecting and analysis of information, providing information in a visual and simple way. On the other hand, through the use of the tool in the JCI program for two months, errors in programming have been detected, and learning has been carried out to identify those points of the tool that have been more complicated to understand. The feedback offered by both the students participating in the project, as well as the professors and the support research staff, has been decisive in identifying ways for improvement. In relation to the learning method, the students have followed a process in which they have been developing skills that have helped them to develop four projects that will be exhibited in the 8th congress of Youth with Researchers, where the tool has been a transversal aspect in work developed. Within the stages defined in the method, the students have managed to complete the first two phases satisfactorily.

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Nomenclature

ECF4CLIM – European Competence Framework for a Low Carbon Economy and Sustainability Through Education

JCI – Youth with Researchers

MS – Microsoft

M365E5 – License E5 Microsoft 365

KPI – Key Performance Indicator

AAD – Azure Active Directory

CSIC – Consejo Superior de Investigaciones Científicas (Spanish National Research Council)

SADC – Sociedad Andaluza para la Divulgación de la Ciencia (Andalusian Society for the Dissemination of Science)

US – University of Seville

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