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Enhancing Curricular Integration of the SDGs: Fostering Active Methodologies through Cross-Departmental Collaboration in a Spanish University

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Enhancing Curricular Integration of the SDGs: Fostering Active Methodologies through Cross-Departmental Collaboration in a Spanish University

Abstract

Purpose – This study **assesses** the effectiveness of active teaching methodologies, namely problem-oriented learning and the case method, to develop sustainability competencies. **It also analyses** the **advantages and challenges for teachers** when implementing the Sustainable Development Goals (SDGs) **in eight undergraduate and postgraduate degrees within the framework of a cross-departmental collaboration**.

Design/methodology/approach – A mixed research methodology was used: a quantitative study to assess the levels of acquisition of sustainability and research competencies and the potential correlation between them; as well as a mixed study of the advantages and challenges for the teachers participating in the cross-departmental initiative. Curriculum content linked to the SDGs was worked on. Active teaching methodologies and a competency assessment rubric were used as curriculum implementation strategies in the eight courses involved**.**

Findings – Active teaching methodologies are suitable to implement the SDGs in university teaching, and to develop both sustainability and research competencies. A synergic effect is observed between them. Coordinated work between teachers of different subjects in several degrees contributes to developing a culture of sustainability at university.

Research limitations/implications – Although the collaboration between teachers from different disciplines was successful, the study did not promote interdisciplinary projects among students from different degrees. This promises to be highly valuable for future research**.**

Practical implications – Students can become present and future leaders in achieving the SDGs. This approach can be replicated in other educational institutions.

Social implications – The study bridges the gap between theoretical recommendations and the practical implementation of the SDGs in undergraduate and postgraduate degrees**.**

Keywords – Sustainable development goals; education for sustainable development; sustainability competencies; research competencies; transformative education; teaching innovation

Article classification – Research paper

1. Introduction

The paradigm shift of achieving the sustainable development goals (SDGs) in our societies is attained through education and learning (UNESCO, 2014). Universities play a key role (Alam *et al.,* 2021; SDSN, 2017, 2020) in this process. The complexity of current socio-environmental world problems like climate change shows it is impossible to understand problems and find solutions to mitigate them unless it is through cross-curricular skills that address complex challenges (SDSN, 2020). Universities are responsible for training citizens and future professionals. Addressing the implementation of the SDGs at universities through the collaboration of multiple actors is therefore key (SDSN, 2020). It enables students to lead their own learning process addressing real-world problems (Brundiers and Wiek, 2013; SDSN, 2017, 2020; Tejedor *et al*., 2019).

In Spain, the Conference of Rectors of Spanish Universities (CRUE), the Ministry of Universities, and the National Agency for Quality Assessment and Accreditation (ANECA) are working on including the SDGs in university curricula (CRUE, 2023a, 2023b) under the provisions of Royal Decree 822/2021, which establishes the quality assurance procedure (BOE, 2021). Article 4.3 of Royal Decree 822/2021 calls for incorporating values and principles linked to the SDGs, as well as cross-curricular sustainability competencies in university curricula (BOE, 2021). These values refer to adopting ethical attitudes towards climate change (Chuvieco, 2022), human rights, and promoting equity, amongst others (BOE, 2023 articles 2 and 18). The *Getting started with the SDGs in universities* guide states that "the SDGs provide an organising structure for universities. Furthermore, given the critical role of universities in ensuring the success of the SDGs, their moral imperative is to embody support for the SDGs as part of their social missions and core functions" (SDSN 2017, p. 7).

The reason why sustainability and the SDGs should be addressed at universities is not merely a matter of reputation and competitive advantage. Universities should be socially committed institutions in an increasingly globalised world (BOE, 2021).

Incorporating competencies related to Sustainability or Education for Sustainable Development (ESD) into university curricula in all the degrees of the Spanish University System was first recommended in the institutional document published by the CRUE in 2012 (CRUE, 2012). Since the approval of the 2030 Agenda (UN, 2015), several papers on implementing the SDGs at universities have been published, both in national and international journals.

However, it seems that the above-mentioned recommendations are not enough to encourage university teachers to implement them. There is a lack of teaching resources and of institutional support to address ESD in their teaching practice (Persson *et al.,* 2023; UNESCO, 2021; Wang *et al.,* 2022). Rigid syllabi and curricula, and a lack of knowledge of the SDGs and ESD are part of the barriers and difficulties encountered by teachers (SDSN, 2020; UNESCO, 2021).

Recommendations to implement the SDGs and ESD in university teaching include using active teaching methodologies (CRUE, 2023a; Rieckmann, 2018, Wiek *et al.* 2014). Other suggestions are carrying out exploratory, transformative, and action-oriented learning (SDSN, 2017, 2020; UNESCO, 2014). Said methodologies should connect competencies for sustainable development (SD) with research competencies (Lambrechts and Van Petegem, 2016), and should address ESD and the SDGs in a collaborative manner (Mokski *et al*., 2023; SDSN, 2020). All those proposals were considered in this cross-departmental collaboration to implement the SDGs in

university teaching. We therefore decided to design a teaching intervention based on active teaching methodologies (project-oriented learning and the case method) in a collaborative setting (Fuertes *et al.*, 2019), oriented to develop both sustainability and research competencies. Moreover, the decision to include research competencies also offered several advantages. First, the development of research competencies seems especially relevant in a higher education context. Second, it allowed the students to choose more complex projects and cases which otherwise would not be approached. Finally, it enabled providing additional evidence for a synergic effect between sustainability and research competencies, as suggested by some preliminary studies (Albareda-Tiana *et al.*, 2018; Lambrechts *et al.*, 2013; Lambrechts and Van Petegem, 2016). The implications of this synergic effect are important for higher education, as will be explained in the discussion section.

Implementing ESD and the SDGs at universities is not solely aimed at one kind of professional. We should all develop cross-curricular SD competencies (SDSN, 2020) to be able to address the complexity of socio-environmental issues (SDSN, 2017). The SDGs and SD competencies should therefore be implemented in all university degrees in a cross-curricular manner (BOE, 2021; CRUE, 2019; SDSN, 2020). However, studies on how to go about it are still scarce (Miñano and García Haro, 2020; Persson *et al.*, 2023). It is necessary to bridge the gap between theory and practice by teaching how to implement the SDGs at university. This study aims to find out if using active teaching methodologies in a cross-departmental initiative is a suitable way of addressing this challenge. To this end, the following research questions (RQs) were formulated:

RQ 1: What is the effectiveness of using active teaching methodologies to develop both sustainability and research competencies with undergraduate and postgraduate students?

RQ 2: What are the advantages and challenges university teachers experience when implementing the SDGs in a cross-departmental collaboration?

2. Background

As educational institutions, universities should contribute to the mission of providing a service to society through the transfer of knowledge, paying special attention to the ethical values inherent in sustainability (UNESCO, 2022). The SDGs address the global challenges the world faces (CRUE, 2019; SDSN, 2017, 2020), and their integration into higher education is a key mission for universities (BOE 2021, 2023; SDSN, 2020). The interaction between university curricula and socio-environmental issues offers students the opportunity of becoming global citizens (UNESCO, 2022).

During the first decades of the 21st century, most scientific publications regarding sustainability in the context of higher education have focused on technical aspects, such as carbon footprint, or the sustainable management of university campuses (Wals, 2012). However, the integration of sustainability into university curricula is given less attention to (Leal Filho *et al.*, 2021). Although significant progress is made with regard to including sustainability, the area of teaching still presents serious challenges (Antúnez *et al.*, 2017).

Implementing the SDGs does not only require knowledge creation. A change in teaching methods (UNESCO, 2020) and in the methodological strategies related to ESD (Albareda-Tiana *et al.*, 2018) is also necessary. This includes learning about real-

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world problems in different sectors of society (Ryan and Tilbury, 2013; UNESCO, 2022; Wiek *et al.*, 2011).

The guiding principles to implement the SDGs at universities include the following recommendations to integrate them into university education: developing competencies, including the SDGs in the curriculum, working on interdisciplinarity, and using teaching and learning methods in which students lead their own learning process (SDSN, 2020).

Several studies show the barriers, challenges, and drivers to implement sustainability at universities (Leal Filho *et al.*, 2018). The rigid academic units and overcrowded curriculum may be opposed to the implementation of the SDGs in higher education institutions (UNESCO, 2022). Equipping teachers with viable methodological strategies to integrate the SDGs into their teaching without having to substantially change their syllabi (SDSN, 2020) could be the key to stimulate this process.

The concept of SD in this study is in line with the integrated approach of the 2030 Agenda in which the different dimensions of SD are considered simultaneously. The term ESD hence refers to education that adopts a comprehensive approach of SD. An all-encompassing view of education in which not only knowledge is transmitted, but the development of sustainability competencies is enhanced in students, is taken. Thus, not only informative education, but also transformative education is provided (Rieckmann, 2018). In the formulation of the sustainability competencies worked on in this study, the interrelation between social and environmental aspects is included.

There are different views and interpretations of the concepts of sustainability and ESD (Bianchi *et al.*, 2021). In this study, "sustainable education", referring to education promoting economic and social development (Alam, 2023), and "sustainability in education", encouraging environmental protection, are not used (Dale and Newman, 2005). The terms ESD and sustainability competencies are employed in a broad sense that takes into account the different dimensions of sustainability. We consider that commercialising sustainability in the university (Alam, 2023) goes against the original universal spirit that should prevail in higher education institutions.

This study is framed within the international framework that promotes implementing the SDGs at universities (SDSN, 2020) and the European sustainability competency framework, which defines sustainability competency as follows: "it empowers learners to embody sustainability values, and embrace complex systems in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures" (Bianchi *et al.,* 2022, p. 12). As this practical intervention for integrating the SDGs into university education was carried out at a Spanish university, the recommendations of the Spanish government and the CRUE to implement the 2030 Agenda at the University were considered (BOE, 2021; CRUE, 2023a). In all these reference documents, a comprehensive view of sustainability is presented. A practical and innovative approach of teaching is considered a requirement for universities to adapt to social demand (BOE, 2021).

3. Materials and methods

The research method and the process developed in the work methodology are presented in this section. Table 1 summarises the system established, connecting each of the research questions with the methodology used, and the curriculum implementation methodology of the SDGs.

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Table 1. Research questions, research methodology, and implementation methodology of the SDGs

This educational intervention was carried out during academic year 2021-2022 at a Spanish university. The data of 11 teachers and 322 students from 8 different subjects in 6 different degrees that participated in the activity were gathered.

3.1. Research methodology

This cross-departmental initiative of innovative teaching was made possible because the same curriculum instruments (see Table 1), shared in different subjects during the same time period at the same university, were used. The activity was carried out to measure the impact of the training activities linked to the SDGs and the development of student competencies. The advantages and challenges involved in undertaking collaborative work between teachers from different departments were also analysed.

The data collection and data analysis processes to accomplish the purpose of this study in accordance with the research questions are specified below.

For the first research question, that is, to find out what the effectiveness of active teaching methodologies is to achieve the SDGs, a quantitative research methodology was employed using two measurement instruments. A first instrument was used to measure the students' level of acquisition of sustainability competencies. The second one was employed to measure the level of correlation between the sustainability and research competencies developed by the students. As Lambrechts and Van Petegem (2016) and Rieckmann (2018) claim, acquiring research competencies enables developing sustainability competencies.

The sample to analyse the level of achievement of this research question consisted of a total of 322 students in 8 different subjects (Table 1).

For the second research question, which regards the analysis of the advantages and challenges of implementing the SDGs in university teaching in a collaborative manner, a mixed research methodology using two data collection methods was followed. The first data gathering method was a qualitative research study conducted through the phenomenological analysis of chapters written and published by the participating teachers upon completing the educational intervention. Said chapters contained the results obtained in the subjects taught, as well as initial conclusions (Albareda-Tiana, 2022). The second method was a quantitative study that was carried out through a questionnaire in which the teachers were asked about the opportunities and difficulties experienced in the coordinated implementation of the SDGs upon completing the educational intervention. A Likert-type scale was used in the questionnaire.

The sample for this second research question was the group of 10 teachers that participated in the collaborative initiative of implementing the SDGs. For ethical reasons, the principal investigator of this study did not participate in the questionnaire, although she did implement the SDGs in her subject (Table 1).

3.2. Context of study analysis: curriculum implementation methodology

To develop sustainability competencies and integrate the SDGs in university degrees, the implementation proposals recommended by the working group for incorporating sustainability into the curriculum to apply Royal Decree 822/2021 at Spanish universities were partly followed (CRUE, 2023a). They were the following:

3.2.1. Defining and sharing curriculum content

Table 1 shows the research questions, the associated curriculum implementation methodology and shared instruments, and the chosen research methodologies. The competencies and assessment system the participating teachers shared to implement the SDGs are described below.

A) *Curriculum content linked to sustainability: the SDGs*

In the 8 subjects, the students either developed a research project or a teaching proposal related to one of the SDGs in a specific and practical manner in small groups. In some of the subjects, two SDGs (for instance, clean water (SDG 6) and climate action (SDG 13) were recommended. In the case of the Business Administration subjects, the students were allowed to choose the SDGs they wanted to work on.

B) *Sustainability and research competencies*

The sustainability and research competencies to be worked on and assessed were agreed upon by all the participating teachers.

Amongst the numerous sustainability competencies, the first two proposed by the CRUE (2012) to be worked on in the Spanish university system were selected: 1) critical contextualisation of knowledge, establishing interrelations with the social, economic and environmental problems of sustainability, and 2) sustainable use of resources and prevention of negative impacts on the natural and social environment.

Competency 1 (C1) includes systemic thinking, critical thinking, and contextualisation of problems within the scope of "embracing complexity in sustainability" in the European sustainability competency framework (Bianchi *et al*., 2022, p. 14). Competency 2 (C2) corresponds to "envisioning sustainable futures" and "acting for sustainability" within the European sustainability competency framework (Bianchi *et al*., 2022, p. 15).

As for research competencies, ESD experts maintain they can only be developed and assessed in practice (Rieckmann 2018; Wiek *et al*., 2011). Lambrechts and Van Petegem (2016) show the interrelations between competencies for sustainable development and research competencies. This study therefore promotes and assesses both types of competencies. The students' sustainability and research competencies are assessed so as to study the level of correlation between them. The research competencies assessed are: (C3) justification of the results obtained and proper use of charts, and (C4) appropriate communication, both orally and in writing.

Previous studies (Albareda-Tiana, *et al*., 2018) showed the correlation between the research competencies presented by Lambrechts and Van Petegem (2016), and the research competencies used in this study. Competency 3, "justification of the results obtained and proper use of charts", includes processing data, drawing reasoned and argued conclusions, and assessing research (Albareda-Tiana *et al.,* 2018, based on the research competencies by Lambrechts and Van Petegem, 2016). Competency 4, "appropriate communication, both orally and in writing", is equivalent to the research competency: "determine and argue a position or opinion" (Albareda-Tiana *et al.,* 2018, based on the research competencies by Lambrechts and Van Petegem, 2016).

C) Competency assessment rubric

The eleven teachers that implemented the active methodologies to integrate the SDGs into university teaching used the same rubric to assess the students' level of acquisition of sustainability and research competencies.

The rubric to assess the four competencies (two sustainability competencies and two research competencies) is the result of previous studies (Table 2). This rubric was designed based on sustainability competencies (CRUE, 2012). In the EDINSOST project (Albareda-Tiana *et al.*, 2020), three levels of competency were established in accordance with Miller's (1990) pyramid, adapted by Fuertes (2014). Some research competencies were added (Lambrechts and Van Petegem (2016) to it.

Miller (1990) established a hierarchy of levels of competency applied to the medical profession, which is easily transferable to other professions (Figure 1). The first level corresponds to knowledge, and is called "knows". The second refers to integrating knowledge and skills, "knows how". Finally, following NCES (2002), the third level of competency associates showing competency in action with the possibility of transferring it to other situations: "shows and does."

Figure 1 shows Miller's pyramid, used in this study to measure the level of competency of the students that carry out research projects, or put forward teaching proposals related to implementing the SDGs.

Table 2. Instrument for assessment of two sustainability competencies and two research competencies using the levels of competency of the simplified version of Miller's pyramid. Source: authors' own work inspired by Albareda-Tiana *et al*. (2018)
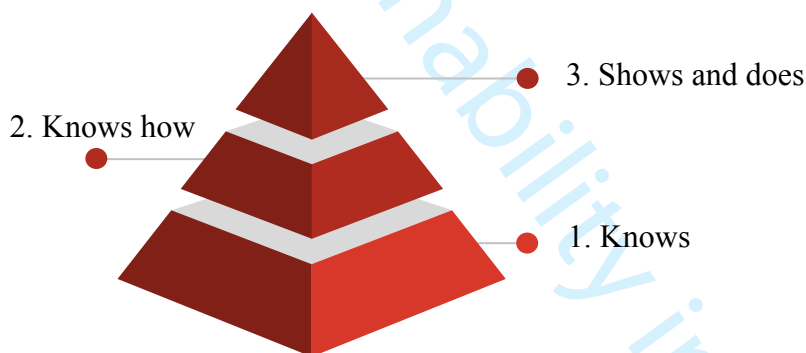

Figure 1. Miller's pyramid (1990)

3.2.2. Active teaching methodologies and sustainability

CRUE-Sustainability also recommends another implementation proposal to incorporate sustainability into university curricula: "promote the coordinated work of teaching teams of different subjects by modules, courses, or semesters, facilitating the inclusion of active and participatory methodologies of a practical nature and of social commitment" (CRUE 2023a, p. 3). This proposal coincides with the common characteristics of pedagogical approaches in ESD (UNESCO, 2014). Coordinated work was carried out by the teachers that used active teaching methodologies and by the students that presented their research projects and teaching proposals in public. It was their way of contributing to the achievement of the SDGs in practice.

A) Coordination in the curriculum implementation methodology

Eleven teachers from the undergraduate degrees of Business Administration, Bioengineering, Medicine, Early Childhood Education, Primary Education, Communication, and a Master's degree in Business Administration, implemented the SDGs in their subjects. Table 3 shows the different degree programmes, the subjects, the teaching methodologies used, and the SDGs the students worked on.

Table 3. Degree programmes, subjects, methodologies used, and the SDGs implemented in the curriculum

B) Active teaching methodologies

As ESD experts claim, the development of competencies can only be achieved and assessed in action (Rieckmann 2018; Wiek *et al*., 2011). Active methodologies are suitable for the development of sustainability competencies (Brundiers and Wiek, 2013). In this study, the methodologies used to implement the SDGs in university education were project-oriented learning (POL) and the case method (CM).

The students, in groups of four to six members, either developed a research project, or a teaching proposal including previous research related to the SDGs selected. They worked on those projects and proposals for approximately two and a half months. During this period, the different groups had two or three tutorial sessions with the teacher. They interacted with agents that were external to the university and specialists in the topics researched. They also consulted numerous sources of information. In this phase, the student groups learnt and developed sustainability and research competencies in a formative and participatory process.

On the first day of the course, the students were told that they would work using a specific methodology (POL or CM), and that the research projects and teaching proposals accounted for 25% of the final mark of the subject. During the first week, they put forward the topic of the project or proposal to be developed during the first tutorial session with the teacher of the subject.

The project-oriented learning (POL) teaching methodology is a teaching-learning method whose predecessors are the fathers of constructivism: Vygotsky, Piaget, and Bruner. Through this methodology, learning is built as an interaction between personal experiences and the network of mental structures developed. It allows students to establish rational and meaningful relationships with the environment and society.

Kilpatrick described POL as early as in 1918. He maintained theoretical learning requires a practical part to base it on. He stated that what matters are not the results, but the processes developed to acquire skills. This idea was recovered two decades ago by the European Higher Education Area (EHEA) calling for a change: from instruction-based education to education based on active learning in which the student is at the centre (Vico, 2014).

The core premise of this strategy is the need to connect theory with practice, allowing the student to solve everyday problems related to the professional context in which they will be developed (Fernandes, 2014). In this research, the students designed the problems to be solved, and those issues were directly related to the SDG they were going to work on.

The phases this teaching-learning methodology follows are: (1) definition/planning/research, (2) implementation/production, and (3) assessment/self-assessment. In the first phase, the students chose the topic, and asked themselves what they knew about it, what they should know, and what they were going to do to acquire the necessary knowledge (learning objectives). The different tasks were distributed amongst the members of the group, and a date was set to share their ideas. In the second phase, the students explained their progress to the members of their group and to the teacher. They shared the results of the tasks assigned. Whatever was necessary was changed, added, or eliminated to give shape to the final product developed, or to the final solution they considered appropriate for the problem posed. Finally, in the third phase, the students orally presented their project or proposal, or the solution to the problem. In the educational intervention described here, the students presented their projects or proposals in public at the university. The presentations were assessed by a group of experts in sustainability, some of whom were external to the university.

The second active methodology applied was the case method (CM). The CM was developed in Harvard Business School in the mid-20th century. It consists of an interactive method used in the classroom in which the teacher assigns a case to the students that they should read and analyse before class. During the class, the students discuss how to interpret the case together and the different ways of acting, to then share their ideas with the teacher. The teacher acts an "orchestra conductor" leading the debate and the solution proposals to get the students to reflect and learn what was planned. The CM helps students achieve practical competencies by giving them the opportunity to apply what they have learnt to a real professional situation (Garvin, 2007).

It is a suitable teaching methodology to acquire and learn competencies related to sustainability (Georgallis and Bruijn, 2022) in which the topics are complex and multidisciplinary. It allows reflecting on and analysing the different problems identified in a specific reality from different perspectives, and the sustainability solutions proposed. It strengthens the development of practical skills, bringing theory closer to practice, and improves both critical thinking and decision-making when facing uncertain prospects.

C) *Public presentation of the students' projects and proposals to the university community and competency assessment*

Every year, since 2009, the Sustainability Office of the university, currently the Office for Cooperation and Sustainable Development, organises a Cross-curricular Sustainability Workshop (CSW). Recently, in May 2023, a congress was held on the SDGs. Those workshops and conferences are meant to make the entire university community reflect on a certain aspect of sustainability in an interdisciplinary and practical manner. Since the approval of the 2030 Agenda in 2015, several SDGs have been addressed every year.

The students present the results of their research projects, or their teaching proposals, to the university community, both in the format of a scientific poster and of a practical workshop. They are assessed by a group of experts who all use the same rubric to assess the students' sustainability and research competencies. During the oral presentation of the projects and proposals, the teachers and experts in sustainability assess the students' level of competency.

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The CSW also contributes to promoting student entrepreneurship. It encourages students to be leaders in the implementation of the SDGs at university (UNESCO, 2017), and to become agents of change (SDSN, 2020).

4. Results

The results regarding RQ 1 (acquisition of sustainability and research competencies) will first be presented, followed by the results related to RQ 2 (advantages and challenges for the teachers).

4.1. Results of the level of attainment of sustainability and research competencies

Following Miller's pyramid (1990), each level of acquisition of sustainability competencies was measured on a scale between 0 and 2, in which 0 - 0.5 means no level of competency is developed; 0.5 – 1 (level 1 is developed, which corresponds to knowledge or "knows"); 1 – 1.5 (acquires level 2 of competency, which corresponds to "knows how"); while 1.5 - 2 means level 3, corresponding to "shows and does".

Figure 2 shows the average values obtained in the different competencies analysed, grouping the research projects and the teaching proposals according to area of knowledge. It also illustrates the level of attainment for C1, C2, C3, and C4, and also for the grouped sustainability competencies (C1 and C2) and research competencies (C3 and C4).

The most homogeneous results between the different degrees are observed in C1, while the greatest dispersion is found in C2. The competency that obtains the highest values is C4: "Appropriate communication, both orally and in writing" (average value 1.73), followed by C3 and C1 (1.57 and 1.56 respectively). Finally, the lowest levels are obtained in C2 (solutions for climate action). They correspond to the level of "knows" in Miller's pyramid. With regard to the different disciplines, the Business Administration students, with the exception of C1, are the ones that persistently obtain lower results. The bioengineering students are found at the other extreme, attaining the highest results. In the other three areas (communication, education, and medicine), the variations are subtle, although medicine seems to be relegated to the last position.
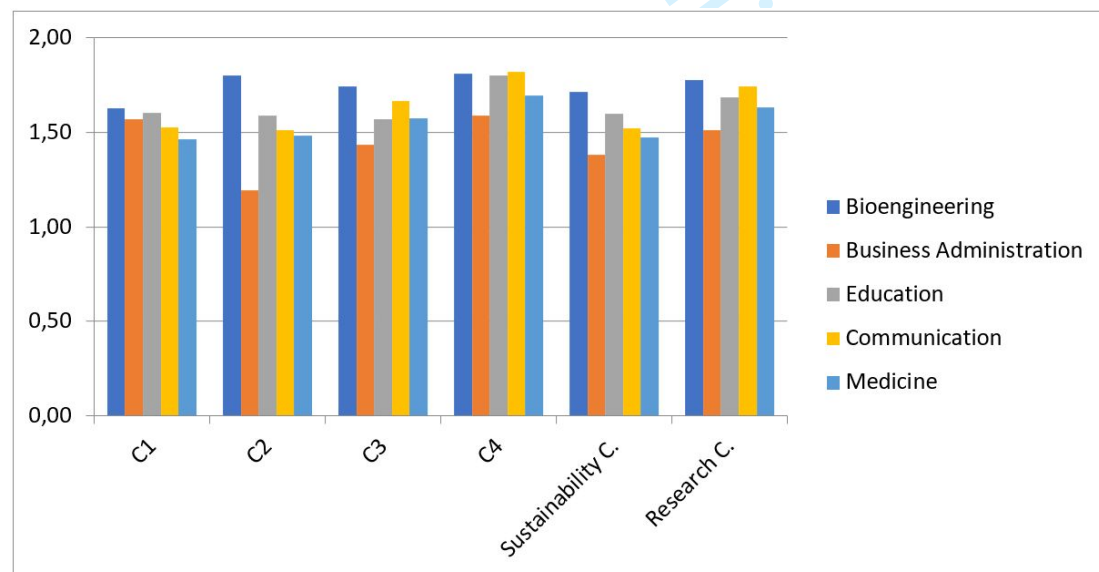

Figure 2. Average values obtained in the competencies, grouping the research projects and teaching proposals by area of knowledge

Table 4 complements the previous graph, and shows the number of projects or proposals -and their percentage of the total- that reached the different levels of attainment of the sustainability competencies. The result is positive, as more than 56% of the projects and proposals are found at the highest level. Only a small part (less than 13%) is found at the basic levels of knowledge or below.

Table 4. Results of sustainability and research competencies according to levels of attainment

Since two different methodologies (CM and POL) were used in the subjects in which this educational proposal was implemented, Figure 3 shows the level of attainment of the four competencies grouped by teaching methodology. It is observed that, while the CM achieves better results in terms of the interrelationships between the three dimensions of sustainability (C1), POL is the methodology that helps the students the most to develop the rest of the competencies. It hence seems to be the most suitable methodology for research-related competencies.
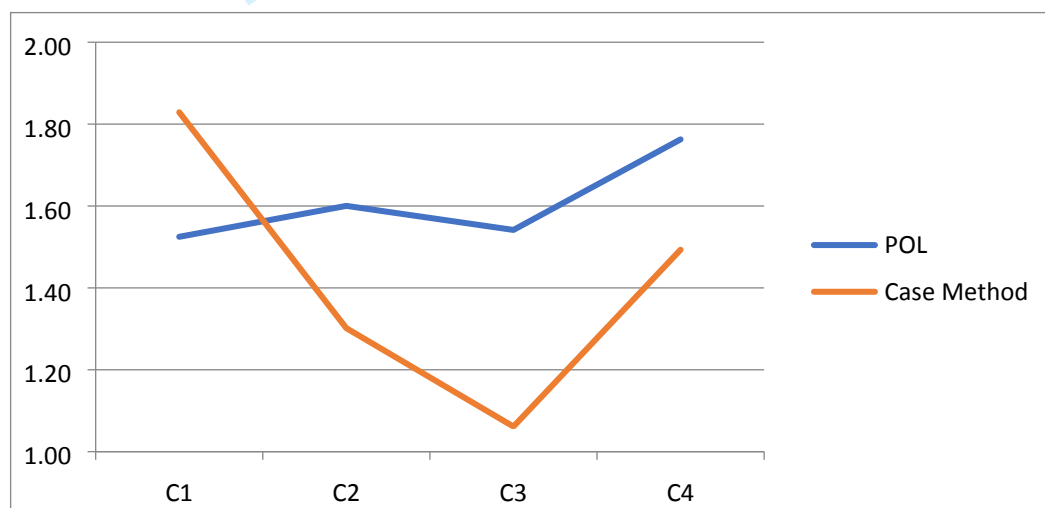

Figure 3. Average values obtained in the competencies distinguished by teaching methodology

Finally, the level of achievement of the competencies is compared in the different years it is implemented (Figure 4). The first-year students are the ones who developed the competencies the best. This might suggest that new generations are increasingly aware of sustainability and/or that they have had greater opportunities of exposure, both in previous educational stages and in a society in which public awareness about sustainability is increasing.
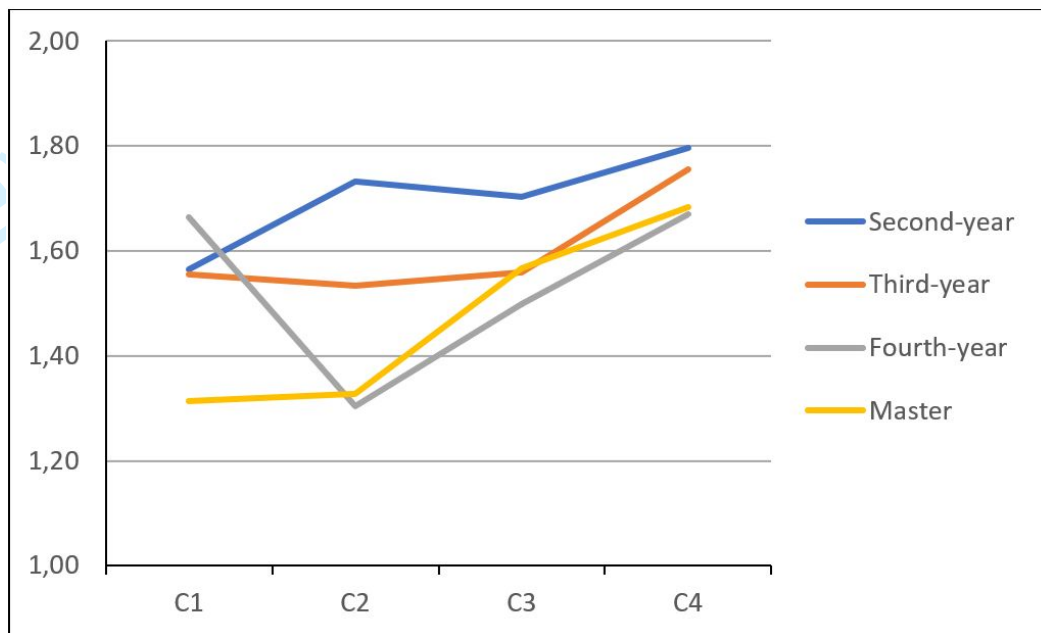
Figure 4. Average values obtained in the competencies per year

4.2. Correlation between sustainability and research competencies

As Lambrechts and Van Petegem (2016) showed the interrelations between competencies for SD and research competencies, this study also analysed the correlation between sustainability and research competencies. Table 5 shows the Pearson correlation coefficients between the different competencies, as well as between the grouped sustainability (C1 + C2) and research (C3 + C4) competencies. The most significant values are highlighted in bold (in brown). The correlations between the individual competencies (C1, C2, C3, and C4) and the grouped competencies that contain them -sustainability and research- are insignificant, and do not provide any relevant information. They are shown in grey.

Table 5. Pearson's correlation coefficients between individual competencies and between grouped competencies of sustainability (C1 + C2) and research (C3 + C4)

The most relevant result of this analysis is the significant level of cross-correlation between sustainability and research competencies, including a particularly remarkable value for the correlation between grouped competencies (0.742). The interpretation of this result is analysed in the discussion section.

4.3. Results of the analysis of the advantages and challenges involved in implementing the SDGs in university teaching in a collaborative manner

To carry out a detailed analysis of the advantages and challenges the implementation of this educational intervention entailed, the opinions and experiences of the teachers participating in this innovative teaching activity were gathered. The results of the final assessment questionnaire the participating teachers completed are shown below. This questionnaire included Likert-type scale questions and open-ended questions. The results of the 5-point Likert-scale are shown in the next section (the options being: totally agree, agree, neutral, disagree, and totally disagree), and the analysis of the participants' responses to the open-ended questions is summarised in a later section.

4.3.1. Responses to the Likert-scale questions

4.3.1.1. What it means for teachers and researchers to participate in this innovative teaching activity
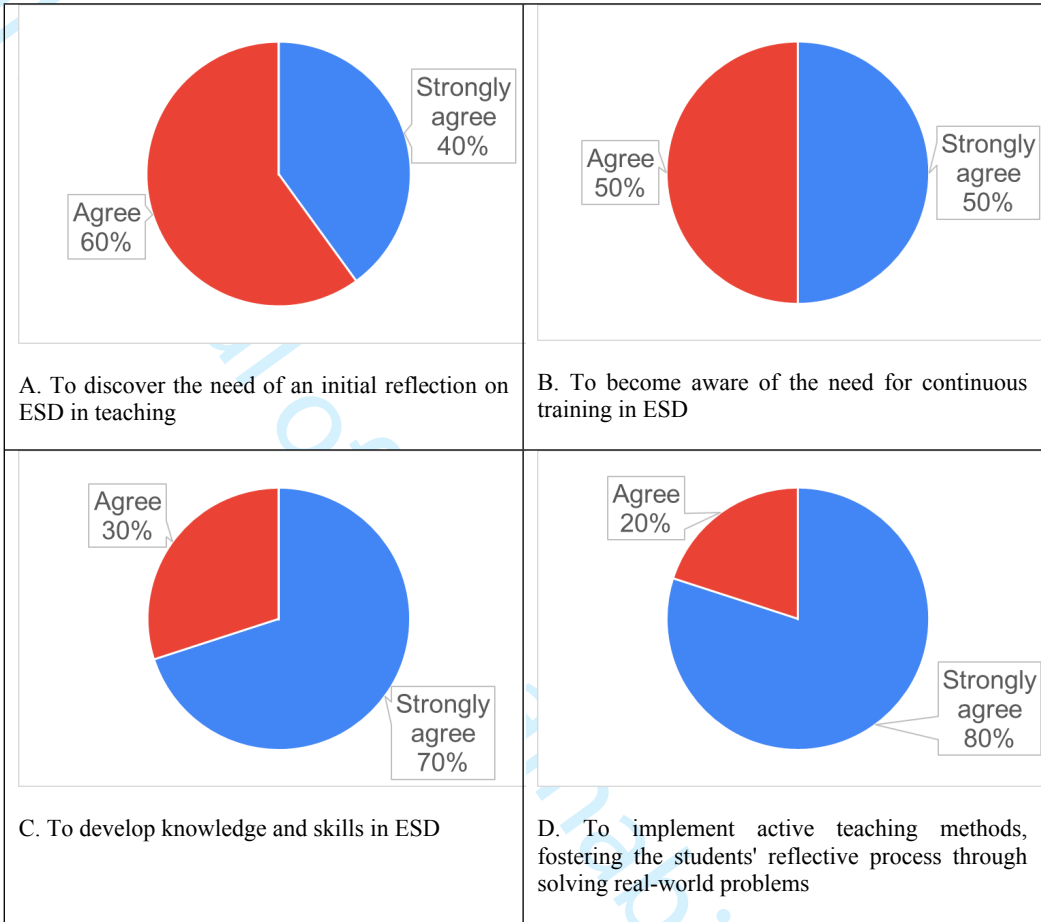

Figure 5. Results of what it means for teachers and researchers to participate in the cross-departmental implementation of the SDGs in a collaborative manner

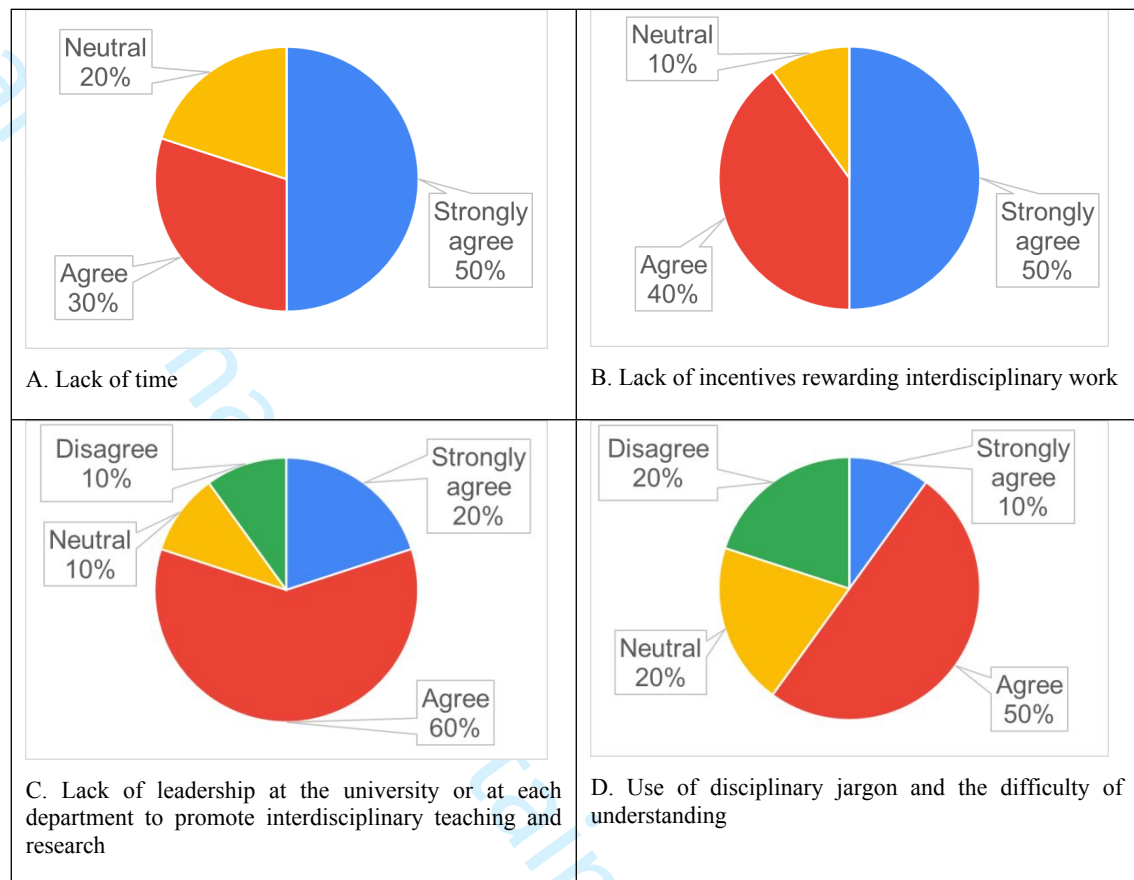*4.3.1.2. Main difficulty or barrier to work in an interdisciplinary manner*

A. Lack of time

B. Lack of incentives rewarding interdisciplinary work

C. Lack of leadership at the university or at each department to promote interdisciplinary teaching and research

D. Use of disciplinary jargon and the difficulty of understanding

Figure 6. Results of the main barriers or difficulties to carry out interdisciplinary work

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4.3.1.3. What the cross-departmental activity of implementing the SDGs means

A. The SDGs and SD must be approached from a holistic and interdisciplinary perspective.

B. The interdisciplinary implementation of the SDGs in the university requires institutional support.

C. Implementing the SDGs in the university is the responsibility of all areas: government, operations, teaching, research, university community, and social responsibility.

D. More training on SD and SDGs is necessary for the entire university community (administration and services staff, teachers and researchers, and students).
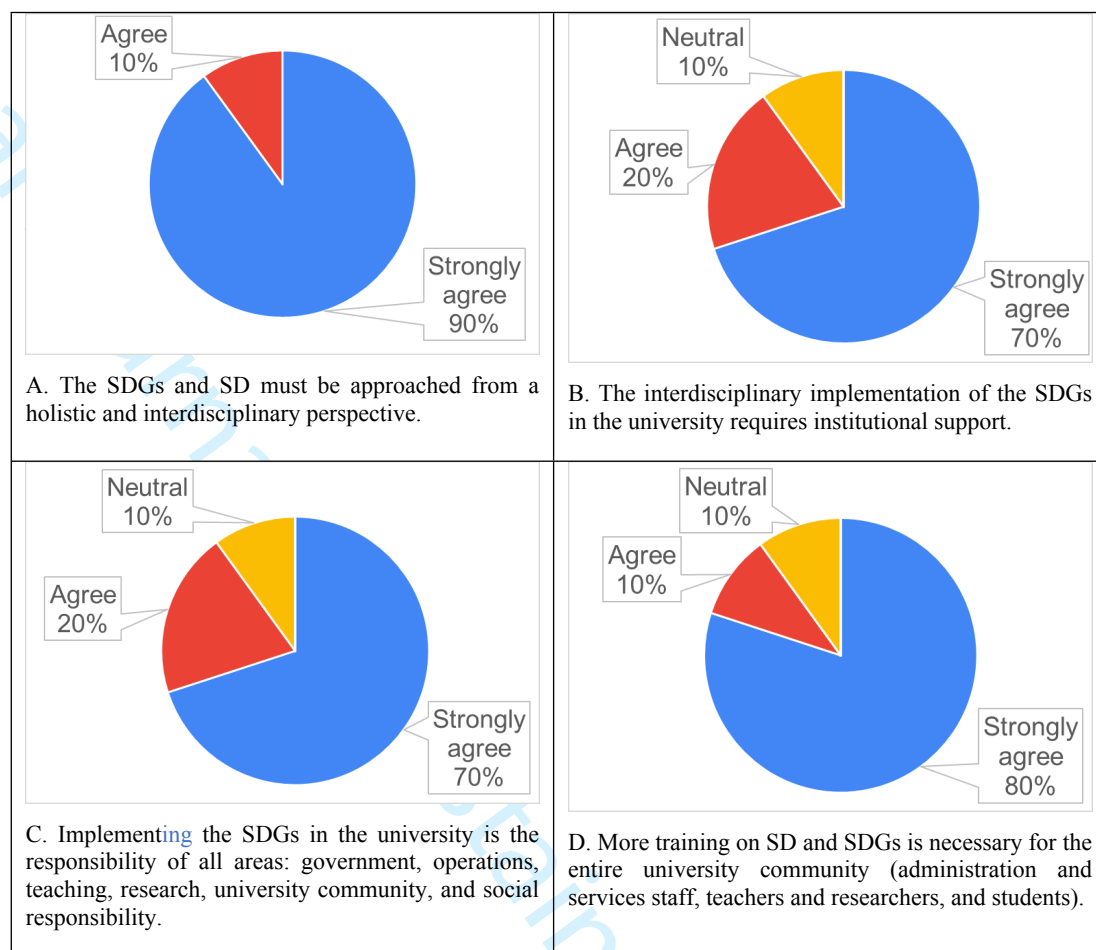
Figure 7. Results of the teachers' opinions on the conclusions of the cross-departmental activity of implementing the SDGs

4.3.2. Responses to the open-ended questions

The questionnaire contained three open-ended questions:

1. Could you highlight which three aspects you found the most interesting in this educational intervention?
2. Could you point out what you have learnt as a teacher in this educational intervention?
3. Which aspects could be improved in the interdisciplinary work to implement the SDGs at university?

The qualitative analysis of the responses received yields the following results. In reply to the first question, the participating teachers mainly highlighted two aspects: the collaborative work between teachers from different disciplines, and the final public presentation of the students' projects and proposals at the student's conference on the SDGs, or at the cross-curricular sustainability workshop. In the teachers' answers to the second question, the following three aspects were stressed: learning active teaching methodologies, learning acquired when implementing the SDGs, and awareness of the value of collaborative work between teachers from different disciplines. The teachers highlighted the activity was an opportunity for establishing synergies between

different university departments, as proposed in other studies (Müller-Christ et al, 2014; SDSN, 2020). As for the third question, the teachers pointed out the need to move from collaborative work to truly interdisciplinary work in which students from different degrees collaborate with each other on the same project.

The results obtained from the educational intervention, including some verbatim quotes that vividly illustrate the experiences of teachers, are analysed at the end of the discussion section.

5. Discussion

With regard to the first research question, *"What is the effectiveness of using active teaching methodologies to develop both sustainability and research competencies with undergraduate and postgraduate students?"*, the results show that 56% of the students of the different degrees (n = 322) reached the highest level -shows and does- in C1 (critical contextualisation of knowledge establishing interrelationships with the social, economic and environmental problems of sustainability), and 61.4% attained this same level in C2 (sustainable use of resources and prevention of negative impacts on the natural and social environment). These results show a medium-high effectiveness (more than half of the sample reached the highest level) of the methodologies used for the development of these competencies. This is the first important finding of our study, and confirms what several ESD experts maintain (Cortese and Hattan 2010; Ryan and Tilbury 2013; Tejedor *et al.*, 2019; UNESCO 2014; Wiek *et al.*, 2014). This first finding constitutes additional evidence, and suggests that active teaching methodologies should be considered as suitable practices to acquire sustainability competencies related to the SDGs.

The correlation between sustainability and research competencies was also studied. Table 3 shows the Pearson correlation coefficients between individual competencies and between the grouped competencies of sustainability (C1 + C2) and research (C3 + C4). The significant level of cross-correlation is striking, and it is the second—and probably the most important—finding of this study. This result suggests a possible synergic effect between the acquisition of sustainability competencies and research competencies, although studies using a control group should be carried out to confirm this. These results are consistent with the proposals of previous studies (Albareda-Tiana *et al.*, 2018; Lambrechts *et al.*, 2013; Lambrechts and Van Petegem, 2016). They suggest that the effective implementation of sustainability competencies requires a holistic approach. This approach stresses interdisciplinarity, and complex and systemic thinking (worked on in both the sustainability and research competencies) to overcome the frequent fragmentation of knowledge and perspectives in higher education. This interpretation serves as the basis for conceiving a comprehensive general competency of "sustainability research and problem-solving", as advocated by multiple previous studies (Wiek *et al.*, 2011). It focuses precisely on the kind of transformation the SDGs want to bring about. The high cross-correlation between sustainability and research competencies serves as a preliminary support for this holistic interdisciplinary approach. It also confirms the usefulness of working on sustainability through the SDGs and through active teaching methodologies. Implications of this result for higher education are twofold. First, the effectiveness of courses on sustainability may increase if research-oriented activities are incorporated into their instructional design. Second, courses on research methods can prioritise sustainability-related topics as a way to increase their effectiveness. Furthermore, this result may lead to another interpretation

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with implications for society at large: sustainability is a complex challenge that requires a transdisciplinary approach based on sophisticated cognitive skills. Therefore, promoting complex thinking is a useful way of contributing to the sustainability challenge.

As for the second research question, "*What are the advantages and challenges university teachers experience when implementing the SDGs in a cross-departmental collaboration?*", the analysis of the results obtained from the questionnaire completed by the teachers, and from the phenomenological analysis of the chapters written by the participating teachers upon completing the educational intervention, reveal the following advantages and challenges:

With respect to the advantages, 100% of the teachers agree or totally agree that their participation in this activity has helped them become aware of the need for continuous training in education for sustainability (Fig. 5-B). As proposed in the report regarding the implementation of Royal Decree 822/2021 on the incorporation of sustainability in university curricula, university governance should provide teachers with training in sustainability and the SDGs (CRUE, 2023a).

Likewise, 100% agree or totally agree that this educational intervention served to generate critical reflection among students on real sustainability problems (Fig. 5-D), and to seek solutions to solve them to the best of their abilities. An early childhood education teacher commented: "It is everyone's responsibility to mould professionals that have a cross-curricular perspective that can combat sustainability problems, and provide opportunities for change and improvement" (Albareda-Tiana, 2022, p. 103). According to the results of Fig. 7-A, 90% of the teachers strongly agree, and 10% agree that the SDGs and sustainable development should be addressed in a holistic manner (Fig. 7-A). The systemic view of sustainable development is shown in the preamble to the 2030 Agenda (UN, 2015). All the reports and guides for the implementation of the SDGs at university stress the need to adopt a systemic view, and highlight the importance of the interlinkages between the different SDGs (SDSN, 2020; UNESCO, 2017).

In agreement with ESD experts and with the SDSN guides for the implementation of the SDGs (Leal Filho *et al.*, 2016; SDSN, 2020), teachers stress that using active teaching methodologies (POL and CM) in the classroom fostered students' reflection through working with real-world problems related to the SDGs (Fig. 5-D). Two teachers of the Management & Operations Master's degree, said "it enabled students to experience the development of a real project exercising the role of project manager first-hand, including everything it entails, awakening their most entrepreneurial and creative side" (Albareda-Tiana, 2022, p. 161).

In short, using active teaching methodologies to implement the SDGs at university, developing sustainability and research competencies, means offering an education that is not only informative, but also transformative (Rieckmann, 2018).

One of the participating teachers commented: "From the results obtained, it is observed how active and participatory methodologies help future professionals introduce social knowledge applied to the profession. Our professional realities increasingly require greater interdisciplinarity" (Albareda-Tiana, 2022, p. 102).

Furthermore, 80% of the teachers strongly agree that more training on sustainable development and the SDGs is key in the whole university community (Fig. 7-D). A bioengineering teacher explained that "the initiative promoted a sense of belonging to the university project and increased the students' motivation" (Albareda-Tiana, 2022, p. 118). Participating in projects linked to the SDGs contributes to empowering and motivating students to become active drivers in shaping a sustainable future (UNESCO, 2017; SDSN, 2020).

With regard to the aspects of the educational activity the teachers found the most interesting, the majority pointed out that collaborative work between teachers from different departments was a fruitful and valuable learning experience. A teacher highlighted "the need to continue working in an interdisciplinary manner, knowing that teachers also learn from the process and from their colleagues who teach other subjects at the same time" (Albareda-Tiana, 2022, p. 103).

As for the challenges the teachers faced, one of the main difficulties expressed by the respondents (50% strongly agree, Fig. 6-A) was the lack of time and of incentives. Developing an activity of such characteristics implies proper time management before, during, and after the activity. A teacher of the early childhood and primary education degrees commented that, "in order to develop the activity, teachers need time for the internal and external management it entails. They need institutional support to carry it out, maintain, and improve it. Institutionalisation and recognition are necessary to ensure the sustainability of initiatives like this" (Albareda-Tiana, 2022, p. 77). This comment is in line with what the ESD for 2030 Roadmap recommends. It encourages "educators around the world to have the opportunity to develop skills to promote the transformation of society with a view to a sustainable future, and teacher training institutions to systematically integrate ESD" (UNESCO, 2020, p. 23). In general, implementing the SDGs at Spanish universities is still an incipient activity (Miñano and García Haro, 2020). For this type of activities to be fully integrated into the university, institutional support from the entities themselves is required (SDSN, 2020).

The *need to* give up on *certain content* in each subject is also stressed. Carrying out a coordinated educational intervention in several subjects in different degrees means all the subjects involved have to align and comply with a series of characteristics to ensure the activity is done uniformly. Teachers have to adapt and eliminate certain activities included in the teaching guides prior to implementing the SDGs in the different subjects. Despite these extra efforts required to adapt and align the subjects, they agree that the *students' benefits* exceed what has to be eliminated, which means the results are satisfactory. According to one of the teachers, "participating in an interdisciplinary activity requires removing part of each subject, but what students gain exceeds it" (Albareda-Tiana, 2022, p. 104).

The above-mentioned list of advantages and challenges is the third relevant finding of this study, which we hope will encourage other universities to implement cross-departmental initiatives. The advantages are considerable. They include increased motivation and a growing awareness of the need for a complex, holistic, and transdisciplinary approach to sustainability. Acknowledging the challenges set forth, such as the extra workload this implementation may entail, the lack of incentives, the need for official institutional support, and the need to give up on other contents, may help other universities optimise their implementation of similar initiatives.

Research limitations

As far as contextual limitations are concerned, it is important to note that the data were gathered in a Spanish university. While there is potential for replication and transferability, caution is advised when generalising the results to other contexts. The second aspect pertains to methodological and technical considerations, specifically the instruments and data collection process. Sustainability and research competencies were derived from the contextual framework, and evaluated upon the completion of the implementation process. In future studies, including pre and post-tests could enhance the research design. Despite these acknowledged limitations, the research underscores its impact on the participants. The qualitative insights complement the quantitative data gathered. However, we acknowledge the limitations of the present study, such as the absence of interdisciplinary projects among students from different degrees despite the successful collaboration among teacher from diverse disciplines. Encouraging collaborative activities among students from different degrees would naturally extend this research, fostering a broader spectrum of perspectives and problem-solving approaches aligned with the intricate and interconnected nature of sustainability challenges of education for sustainability.

6. Conclusions

This study focused both on assessing the effectiveness of using active teaching methodologies for undergraduate and postgraduate students to acquire competencies related to sustainability and research, and on the advantages and challenges this represented for the teachers who participated in a cross-departmental initiative for this purpose. It is important to stress that it is one of the first studies of this nature in the Spanish higher education system.

This is particularly striking because both international (SDSN 2017, 2020; UNESCO, 2022) and Spanish institutions for governance in higher education (CRUE 2012, 2023a, 2023b) have made repeated calls with respect to broadening knowledge about incorporating the SDGs in higher education. This knowledge may act as a multiplicative factor, guiding universities towards implementing those practices that have proven effective. This study is hence a good example of how the gap between theory and practice can be bridged.

The conclusions drawn from the results concerning the research questions formulated can be summarised as follows:

First, the results obtained show that active teaching methodologies effectively contribute to the development of sustainability competencies, thus promoting transformative education. By encouraging students to actively participate, and providing them with opportunities to research and explore, greater knowledge, abilities and attitudes related to sustainability are attained. An education that is not only informative, but also transformative, is thus achieved, as the students themselves change. Furthermore, promoting research activities through active methodologies such as POL and CM contributes to achieving sustainability competencies.

Second, a correlation is observed between high levels of sustainability competencies and research competencies, suggesting a synergic effect between them. This result has significant implications for higher education: courses that aim to integrate the perspective of sustainability may become effective by incorporating research-oriented activities, and courses of research methods can prioritise sustainability-related topics as a way to increase their effectiveness.

Third, the analysis of the advantages and challenges for the teachers that participated in the cross-departmental initiative shows significant advantages, such as increased motivation and a growing awareness of the need for a complex, holistic, and transdisciplinary approach to sustainability. However, it also reveals challenges, such as the extra workload this implementation may entail for teachers, together with the lack of tangible incentives, the critical need for official institutional support, and the need to give up on other contents in their subjects. In conclusion, the initiative required an attitude of openness and flexibility on behalf of the teachers, which gave rise to a rewarding and enriching experience.

The educational intervention presented in this study is hence not only about student learning. It also provides an opportunity for innovation and growth for teachers. Collaboration between different disciplines is a challenge that allowed us to broaden horizons, and address the challenges related to sustainability in depth.

Finally, this cross-departmental collaboration to implement the SDGs in university education can be replicated in other academic environments. The study is bridging the gap between the theoretical recommendations included in laws (BOE, 2021, 2023), guides, and reports, and the practical implementation of the SDGs at university.

7. References

Alam, G. M., Roslan, S., Al-Amin, A. Q., and Leal Filho, W. (2021), "Does GATS' influence on private university sector's growth ensure ESD or develop city 'Sustainability Crisis'—Policy framework to respond COP21", *Sustainability*, Vol.13 No. 8, pp. 4520-4541.

Alam, G. M. (2023), "Sustainable Education and Sustainability in Education: The Reality in the Era of Internationalisation and Commodification in Education—Is Higher Education Different?", *Sustainability*, Vol.15 No.2, pp.1315-1322, available at: https://www.mdpi.com/2071-1050/15/2/1315

Albareda-Tiana, S. (2022), "Metodologías docentes activas para implementar los ODS de manera interdisciplinaria en UIC Barcelona", Kit-Book Serveis Editorials (Ed), S.C.P. ISBN: 978-84-125693-9-1, available at: https://repositori.uic.es/handle/20.500.12328/3545

Albareda-Tiana, S., Ruíz-Morales, J., Azcárate, P., Valderrama-Hernández, R., and Múñoz, J. M. (2020), "The EDINSOST project: Implementing the sustainable development goals at university level", *Universities as Living Labs for Sustainable Development: Supporting the Implementation of the Sustainable Development Goals*, pp. 193-210.

Albareda-Tiana, S., Vidal-Raméntol, S., Pujol-Valls, M., Fernández Morilla, M. (2018), "Holistic approaches to develop Sustainability and Research Competencies in Pre-service Teacher Training", *Sustainability*, Vol. 10, pp. 3698-3718, available at: https://doi.org/10.3390/su10103698

Antúnez, M., Gomera, A., and Villamandos, F. (2017), "Sostenibilidad y currículum: Problemática y posibles soluciones en el contexto universitario español, Profesorado. *Revista de Currículum y Formación de profesorado*, Vol. 21 No. 4, pp. 197-214.

Bianchi, G., Pisiotis, U., Cabrera Giraldez, M., Bacigalupo, M., Punie, Y. (Eds.) (2022), *GreenComp*. "The European sustainaibility competence framework",

EUR 30955 EN, Publications Office of the European Union, Luxembourg, 2022; ISBN 978-92-76-46485-3, doi:10.2760/13286, JRC128040

Boletín Oficial del Estado (BOE) (2021), Real Decreto 822/2021, de 28 de septiembre, por el que se establece la organización de las enseñanzas universitarias y del procedimiento de aseguramiento de su calidad, available at: https://www.boe.es/buscar/act.php?id=BOE-A-2021-15781

Boletín Oficial del Estado (BOE) (2023), Ley Orgánica 2/2023, de 22 de marzo, del Sistema Universitario, available at: https://www.boe.es/buscar/pdf/2023/BOE-A-2023-7500-consolidado.pdf

Brundiers, K., and Wiek, A. (2013), "Do we teach what we preach? An international comparison of problem-and project-based learning courses in sustainability", *Sustainability*, Vol. 5 No. 4, pp.1725-1746.

Chuvieco, E. (2022), "Observación de la Tierra y cambio climático: ¿Qué sabemos y cómo respondemos?", *Real Academia de Ciencias*, Vol. 111, No. 1, pp. 69-76.

Cortese, A. D., and Hattan, A. S. (2010), "Research and solutions: Education for sustainability as the mission of higher education", *Sustainability: The Journal of Record*, Vol. 3 No. 1, pp. 48-52.

CRUE-Sostenibilidad (2012), "Directrices para la introducción de la Sostenibilidad en el Currículum", available at: http://www.crue.org/Documentos%20compartidos/Declaraciones/Directrices_Sosteniblidad_Crue2012.pdf

CRUE-Sostenibilidad (2019), "El compromiso de las universidades españolas con la Agenda 2030", available at: https://www.crue.org/wp-content/uploads/2021/11/CRUE-Universidades-Espanolas.-Posicionamiento-Agenda-2030.pdf

CRUE-Sostenibilidad (2023a), "Informe de aplicación del Real Decreto 822/2021. Sobre la inclusión de la sostenibilidad en los planes de estudios universitarios", available at: https://www.crue.org/wp-content/uploads/2023/05/Informe-SostenibilizacionCurricular.pdf

CRUE-Sostenibilidad (2023b), CRUE y ANECA trabajan en la inclusión de los ODS en los planes de estudio universitarios, available at: https://www.crue.org/2023/06/crue-y-aneca-trabajan-inclusion-ods-planes-de-estudio-universitarios/

Dale, A., and Newman, L. (2005), "Sustainable development, education and literacy", *International Journal of Sustainability in Higher Education*, Vol. 6 No. 4, pp. 351-362.

Fernandes, S.R.G. (2014), "Preparing Graduates for Professional Practice: Findings from a Case Study of Project-Based Learning (PBL)", *Procedia Social and Behavioral Science*, Vol. 139, pp. 219–226.

Fuertes, M.T. (2014), "El ApS en el Prácticum de la formación inicial del profesorado", available at: http://hdl.handle.net/10803/104577
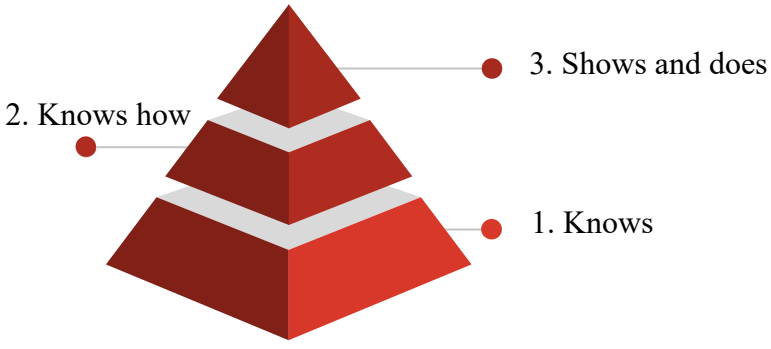
Fuertes, M.T., Graell, M., Fuentes, M., and Balaguer, M. C. (2019). "Integrating sustainability into higher education curricula through the project method, a global learning strategy". *Sustainability,* Vol.11 No. 3, pp.767-791, available at: https://doi.org/10.3390/su11030767

Garvin, D. A. (2007), "Teaching executives and teaching MBAs: Reflections on the case method", *Academy of Management Learning & Education*, Vol. 6 No. 3, pp. 364-374.

Georgallis, P. and Bruijn, K. (2022), "Sustainability teaching using case-based debates", *Journal of International Education in Business*, Vol. 15 No. 1, pp. 147-163. https://doi.org/10.1108/JIEB-03-2021-0039

Kilpatrick, W. H. (1918), "The project method. Teachers College Record", Vol. 19, pp. 319-335.

Lambrechts, W. and Van Petegem, P. (2016), "The interrelations between competences for sustainable development and research competences", *International Journal of Sustainability in Higher Education,* Vol. 17 No. 6, pp. 776-795.

Leal Filho, W., Shiel, C., and Paço, A. (2016), "Implementing and operationalising integrative approaches to sustainability in higher education: the role of project-oriented learning", *Journal of Cleaner Production*, Vol. 133, pp.126-135.

Leal Filho, W., Pallant, E., Enete, A., Richter, B., and Brandli, L. L. (2018), "Planning and implementing sustainability in higher education institutions: an overview of the difficulties and potentials", *International Journal of Sustainable Development & World Ecology,* Vol. 25 No. 8, pp. 713-721.

Leal Filho, W., Will, M., Shiel, C., Paço, A., Arminda, P., Farinha, C. S., Orlovic Lovren, V., Ed.s (2021), "Towards a common future: revising the evolution of university-based sustainability research literature", *International Journal of Sustainable Development & World Ecology,* Vol. 28 No. 6, pp. 503-517.

Miller, G. E. (1990), "The assessment of clinical skills/competence/performance", *Academic Medicine* (Supplement), Vol. 65, pp. 63-67.

Miñano, R. and García Haro, M. (2020), "Implementando la Agenda 2030 en la Universidad: Casos Inspiradores de Educación para los ODS en las Universidades Españolas", Red Española para el Desarrollo Sostenible (REDS) (Eds.)

Mokski, E., Leal Filho, W., Sehnem, S., and Andrade Guerra, J. B. S. O. D. (2023), "Education for sustainable development in higher education institutions: an approach for effective interdisciplinarity", *International Journal of Sustainability in Higher Education*, Vol. 24 No. 1, pp. 96-117.

Müller-Christ, G., Sterling, S., van Dam-Mieras, R., Adomßent, M., Fischer, D., and Rieckmann, M. (2014), "The role of campus, curriculum, and community in higher education for sustainable development–a conference report", *Journal of Cleaner Production*, Vol. 62, pp. 134-137.

National Center for Education Statistics (NCES). (2002), "Defining and Assessing Learning: Exploring Competency-Based Initiatives", *U.S. Department of Education*, available online: https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2002159

Persson, C., Einarson, D., and Melén, M. (2023), "Educating the educators to be a driving force in higher education towards sustainable development", *International Journal of Sustainability in Higher Education*, Vol. 24 No. 9, pp. 197-212.
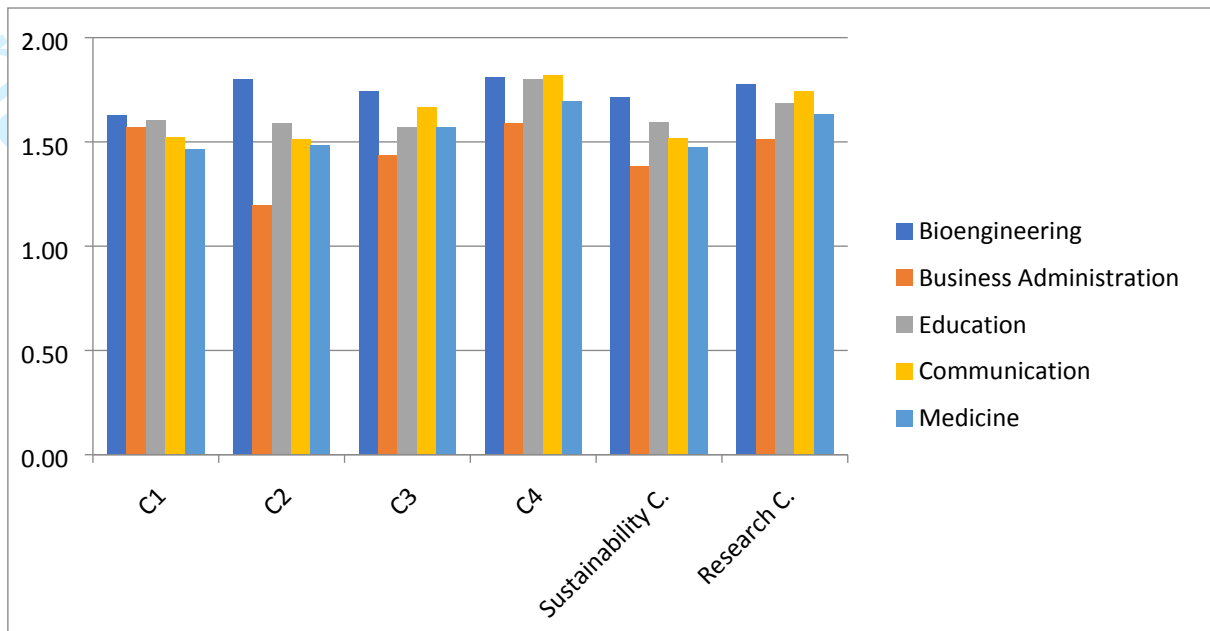
Rieckmann, M. (2018), "Learning to transform the world: key competencies in Education for Sustainable Development". In: Issues and trends in education for sustainable development, UNESCO, pp. 39-59.

Ryan, A., and Tilbury, D. (2013), "Flexible pedagogies: New pedagogical ideas", *Higher Education Academy.*

Sustainable Development Solutions Network (SDSN) (2017), "Getting Started with the SDGs in Universities: A Guide for Universities, Higher Education Institutions, and the Academic Sector", Australia, New Zealand and Pacific Edition. Sustainable Development Solutions Network—Australia/Pacific, Melbourne.

SDSN (2020), "Accelerating Education for the SDGs in Universities: A guide for universities, colleges, and tertiary and higher education institutions", New York: Sustainable Development Solutions Network (SDSN)

Tejedor, G., Segalàs, J., Barrón, Á., Fernández-Morilla, M., Fuertes, M. T., Ruiz-Morales, J., and Hernández, À. (2019), "Didactic strategies to promote competencies in sustainability", *Sustainability,* Vol. 11 No. 7, pp. 2086-2110.

UNESCO (2014), "UNESCO Roadmap for Implementing the Global Action Programme on Education for Sustainable Development", UNESCO Publishing (Ed.), Paris, France.

UNESCO (2017). "Educación para los Objetivos de Desarrollo Sostenible. Objetivos de aprendizaje", UNESCO Publishing (Ed.), Paris, France.

UNESCO (2020), "Educación para el Desarrollo Sostenible. Hoja de ruta. EDS para 2030", available at: https://unesdoc.unesco.org/ark:/48223/pf0000374896

UNESCO (2021), "Teachers have their say: motivation, skills and opportunities to teach education for sustainable development and global citizenship", available at: https://unesdoc.unesco.org/ark:/48223/pf0000379914

UNESCO (2022), "Knowledge-driven actions: Transforming higher education for global sustainability", available at: https://unesdoc.unesco.org/ark:/48223/pf0000380519

UNITED NATIONS (UN) (2015), "Transforming Our World: The 2030 Agenda for Sustainable Development", Resolution adopted by the General Assembly on 25 September 2015, available online: http://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

Vico, B. P. (2014), "Cambios en la metodología docente del espacio europeo de educación superior", *Revista de Estudios y Experiencias en Educación,* Vol. 13 No. 26, pp. 229-245.

Wals, A. E. (2012), "Shaping the education of tomorrow: 2012 full-length report on the UN Decade of Education for Sustainable Development", UNESCO.

Wang, Y., Sommier, M., and Vasques, A. (2022), "Sustainability education at higher education institutions: pedagogies and students' competences", *International Journal of Sustainability in Higher Education*, Vol. 23 No. 8, pp. 174-193.

Wiek, A., Withycombe, L., and Redman, C. L. (2011), "Key competencies in sustainability: a reference framework for academic program development", *Sustainability science*, Vol. 6 No. 2, pp.203-218.

Wiek, A., Xiong, A., Brundiers, K., and Leeuw, S. van Der (2014), "Integrating problem- and project-based learning into sustainability programs. A case study on the School of Sustainability at Arizona State University", *International Journal of Sustainability in Higher Education,* Vol. 15 No. 4, pp. 413-449. https://doi.org/10.1108/IJSHE-02-2013-0013

3. Shows and does

2. Knows how

1. Knows

A. To discover the need of an initial reflection on ESD in teaching.

B. To become aware of the need for continuous training in ESD

C. To develop knowledge and skills in ESD

D. To implement active teaching methods, fostering the students' reflective process through solving real-world problems

A. Lack of time.

B. Lack of incentives rewarding interdisciplinary work.

C. Lack of leadership at the University or at each department to promote interdisciplinary teaching and research.

D. Use of disciplinary jargon and the difficulty of understanding.

A. SDGs and SD must be approached through a holistic and interdisciplinary perspective.

B. The interdisciplinary implementation of SDGs in the university requires institutional support.

C. The implementation of the SDGs in the university is the responsibility of all areas: government, operations, teaching, research, university community, and social responsibility.

D. It is necessary more training on SD and SDGs for the entire university community (administration and services staff, teaching and research staff, and students).

Research questions (RQs)	Curriculum implementation methodology and shared instruments	Research methodology
1. What is the effectiveness of using active teaching methodologies to develop both sustainability and research competencies with undergraduate and postgraduate students?	Curriculum content related to sustainability: the SDGs	**Quantitative methodology** - Level of attainment of sustainability competencies (levels 2 and 3) - Correlation between sustainability and research competencies
	Sustainability and research competencies	
	Assessment rubric of competencies	
2. What are the advantages and challenges university teachers experience when implementing the SDGs in a cross-departmental collaboration?	Coordination in the strategies of implementing the SDGs in the curriculum	**Mixed methodology** - Questionnaire to teachers (Likert-type scale) - Teachers' reflections after completing the project
	Using the same active teaching methodologies	
	Public presentation of the student's research projects or teaching proposals to the university community	

Sustainability competencies and research competencies	Lacks competency mastery	Level of competency according to Miller		
		Knows	Knows how	Shows and does
1. Critical contextualisation of knowledge establishing interrelations with the social, economic and environmental problems of sustainability				
2. Sustainable use of resources and prevention of negative impacts on the natural and social environment				
3. Justification of the results obtained and proper use of charts				
4. Appropriate communication, both orally and in writing				

Degree or Master's degree	Subject (course)	Teaching methodology	SDGs implemented
Economic and social sciences (Business Administration)	Strategic management (4th year subject)	CM	3, 6, 12, 13, 17
	Project management (Master's degree in Management & Operations)	POL	3, 6, 10, 12, 13, 17
Bioengineering	Technology and Society (2nd year subject)	POL	6, 13, 17
Communication sciences	Communication in fashion, trends and sustainability (4th year subject)	POL	3, 6, 12, 13, 17
Medicine	Bio-ethics (3rd year subject)	POL	3, 12, 17
Primary education	Teaching and learning experimental sciences III (3rd year subject)	POL	3, 4, 6, 12, 13, 17
Early Childhood education	Childhood, health and nutrition (2nd year subject)	POL	4, 6, 12, 13
	Learning natural sciences, social sciences, and mathematics III (3rd year subject)	POL	3, 4, 6, 12, 13, 17

Level	Scale	C1	C2	C3	C4
3 – Shows and does	(1.5 – 2]	32 (56.14%)	35 (61.40%)	36 (63.16%)	45 (78.95%)
2 – Knows how	(1 – 1.5]	21 (36.84%)	14 (24.56%)	16 (28.07%)	10 (17.54%)
1 - Knows	(0.5 – 1]	3 (5.26%)	7 (12.28%)	5 (8.77%)	1 (1.75%)
0	[0 – 0.5]	1 (1.75%)	1 (1.75%)	0 (0.00%)	1 (1.75%)

Competencies	C1 (integral sustainability	C2 (sustainable use)	C3 (justification of results and proper use of charts)	C4 (appropriate communication)	Sustainability competency (C1 + C2)
C2 **(sustainable use)**	0,520				
C3 **(justification of results and proper use of charts)**	0,401	**0,708**			
C4 (appropriate communication)	0,508	**0,675**	0,601		
Sustainability c. (C1 + C2)	0,856	0,887	**0,645**	**0,683**	
Research c. (C3 + C4)	0,506	**0,773**	0,901	0,888	**0,742**