Peer-reviewed version available at *Sustainability* **2018**, *10*, 3698; doi:10.3390/su10103698

Article

Holistic Approaches to Develop Sustainable Competencies in Pre-service Teacher Training

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Abstract: Since the Sustainable Development Goals (SDGs) came into effect, both UNESCO and other international organisations recommend empowering youth to implement the SDGs in universities.

Getting started with the SDGs at university level is of special relevance in pre-service teacher training since future teachers are powerful agents of change in the lives of young people.

Future teachers need to acquire competencies in sustainability to be able to promote meaningful changes in sustainable behaviour. To that end, holistic approaches to facilitate their acquirement need to be developed.

The aim of this study is to explore which teaching methodologies are suitable for the development of competencies in sustainability in Higher Education (HE) and how to empower students to take a leading role in implementing the SDGs in universities. The participants in the study are a group of 23 students in pre-service teacher training. The experimental educational model used for the development of sustainable competencies consists of a methodological sequence of Project-Oriented Learning (POL) and a Cross-disciplinary Workshop on Sustainable Food. This study provides evidence that a holistic approach is appropriate for developing sustainable competencies and contributes to empowering students to implement SDG 12 at their university.

Keywords: sustainable competencies; holistic competency; teacher training; project-oriented learning; cross-disciplinary workshop on sustainable food; sustainable food; higher education

1. Introduction

Considering the Earth continues to speed down an unsustainable path, several educational actors identified the need to create programmes [1, 2] to raise citizen awareness and encourage sustainable behaviour. The resolution of the UN General Assembly declaring a Decade of Education for Sustainable Development (2005-2014) emphasised that "education is an indispensable element for achieving sustainable development" [3] (p.1). More recently, the publication by UNESCO: *Education for Sustainable Development Goals. Learning Objectives* [1] highlighted that education is a key instrument to achieve the SDGs. In the same vein, the former Director-General of UNESCO, Irina Bokova, stated: "A fundamental change is needed in the way we think about education's role in global development because it has a catalytic impact on the well-being of

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individuals and the future of our planet. […] Now, more than ever, education has a responsibility to be in gear with 21st century challenges and aspirations and foster the right types of values and skills that will lead to sustainable and inclusive growth, and peaceful living together" [1] (p.7). Higher education institutions (HEIs) play a key role in the implementation of the 2030 Agenda of the United Nations and developing competencies in sustainability at university level is a way to promote it [1]. Future teachers will not be able to provide education to promote sustainable development if they themselves have not acquired the necessary competencies in sustainability [4, 5]. Possessing competencies in sustainability is crucial for future teachers as their influence reaches far beyond the classroom and can contribute to building a more sustainable society [6,7,1]. Not only do teachers have to be knowledgeable and deliver convincing arguments, their behaviour needs to be consistent with what is taught in the classroom. Education to develop sustainable competencies is considered a key element in Education for Sustainable Development Goals [1].

Implementing the SDGs does not only require knowledge creation. A change in teaching methods [1] and in the methodological strategies related to Education for Sustainable Development (ESD) is necessary [8]. This includes learning from real-world problems, anticipating and preparing for future sustainability challenges [9 , 10], core methodologies, integrative thinking and participation [11].

Since the implementation of the European Higher Education Area (EHEA) in universities, competency-based teaching and learning was introduced [12]. In less than two decades, numerous initiatives have been taken to promote competencies in sustainability in HE [10, 13, 14, 15, 16, 17, 18, 19, 20, 21]

Teaching based on competencies in sustainability therefore presents a new challenge for university teachers and more particularly for those who teach future teachers [22, 23, 4], as they have to implement suitable teaching strategies for their students to develop competencies in sustainability [1, 2, 6, 7].

The Conference of Rectors of Spanish Universities (CRUE in Spanish) drafted and approved documents proposing core competencies in sustainability [16], which are the ones used in this experimental educational model. The following four cross-curricular competencies for sustainability are proposed for inclusion in HE:

- SUST1. Competency in the critical contextualisation of knowledge through linking social, economic and environmental issues at a local and/ or global level;
- SUST2. Competency in the sustainable use of resources and in the prevention of negative impacts on natural and social environments;
- SUST3. Competency to participate in community processes that promote sustainability;
- SUST4. Competency to apply ethical principles related to sustainability values in personal and professional behaviour.

Given the need to create holistic approaches to develop Sustainable Competencies in pre-service teacher training, the third year students of the Degree in Primary Education at the *Universitat Internacional de Catalunya* (UIC) in Barcelona were asked to develop a research project related to sustainable food. This project was elaborated through the methodology of Project-Oriented Learning (POL) and its results were presented to the university community at the annual Cross-disciplinary Workshop on Sustainable Food held at the university. These holistic and integrative approaches enabled the development of competencies in sustainability within different educational contexts and they contributed to the empowerment of young people to implement the SDGs at the university. By empowerment we mean the process through which people strengthen their abilities, confidence and perception and acquire prominence as a social group to inspire positive and sustainable change in a given context [7, 24].

The preamble of the 2030 Agenda clearly states that the different dimensions of sustainable development must be implemented in an integrated manner [25]. Both the document of the United Nations Conference on Sustainable Development, Rio +20, aimed at universities [26], and the documents developed by UNESCO to implement the SDGs related to education call for holistic and integrated approaches to sustainable development [1, 11].

It seemed appropriate in the experimental educational model described in this paper to focus on holistic approaches. To this aim, several indicators were developed to measure how the students, future teachers, acquired this holistic vision. In this study, the set of indicators of the holistic vision are referred to as the holistic competency (HC).

By conducting research projects on sustainable food, the students developed competencies in sustainability using a holistic approach. By proposing a research project related to sustainable food, the idea was to address SDG 12, which concerns sustainable food consumption. Sustainable food, in addition to being directly related to health and education, enabled working on the social, environmental and economic dimension of sustainability in an integrated manner, dealing with real everyday problems. When presenting the findings of their research to the university community, the students took a leading role in the implementation of an SDG at their university.

This study aims to answer the following questions:

1. Which teaching methodologies are suitable for the development of competencies in sustainability for the students?
2. Are these methodologies suitable for empowering students to be the protagonists of the implementation of the SDGs in the university they study at?

2. Material and Methods

2.1. Research Methods

2.1.1. Participants

The participants in the research project were 23 students of the Degree in Primary Education of the Faculty of Education at the UIC. The average age of the students was 20,5.

Considering the group of students was very small and assuming that holistic and integrated approaches to develop sustainable competencies were going to be beneficial to all the students, the same methodology was used with the entire group and no control group was included.

2.1.2. Instruments

Two instruments were used in the research process:

a) Rubric for assessment of four competencies in sustainability and one holistic competency, used by experts in the oral presentation of the students' research projects. In this rubric, the five competencies that appear in table 1 are assessed on a scale of 0 to 2, where 0 - 0,5 = lacks command of the competency; 0,5 - 1 poor command; 1 - 1,5 good command and 1,5 -2 = very good command.

   For this purpose, a structure based on four competencies related to sustainability was defined: SUST1-SUST4. Each competency was divided into three levels, which were defined using the levels of competency of the simplified Miller pyramid [27]. To make assessment easier, levels "Shows how" and "Does" were joined into one level.

   Miller (1990) established a hierarchy of competencies in the medical profession (that can also be applied to other professions), which are depicted in Figure 1.

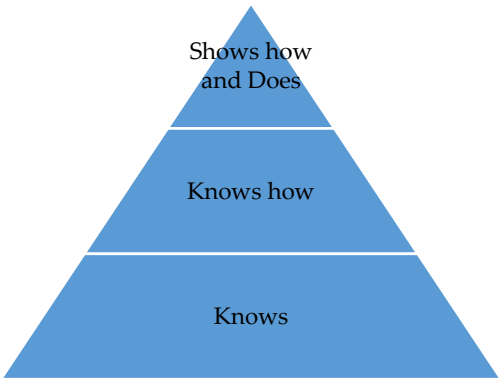

Figure 1. Miller's Pyramid (1990). Source: Authors' adaptation of various versions of Miller's Pyramid, unifying two levels

From the selection of competencies and the hierarchy of results established by Miller (1990), the study focuses on analysing what the learning outcomes allow us to evaluate. It established three levels of acquisition defined by learning outcomes (indicators), based on the standards set by the National Centre for Education Statistics of the United States [28].

The first level corresponds to knowledge and refers to learning, the second level corresponds to integration and development in the situation and finally, the third level is related to demonstrating competency in the action and the possibility of transferring this action.

b) Rubric for assessment of the competence in sustainability and the holistic competence, used by the teachers of didactics of mathematics, science and language, in the written presentation of the students' research projects. In this rubric, the competence in sustainability and the holistic competence that appear in Table 2 are assessed on a scale of 0 to 2, in the same way as in the rubric mentioned earlier. The holistic competence is analysed by means of four different indicators.

2.2. The Research Process. Pedagogical Holistic Aproaches to develop Sustainable Competencies

Working on competencies in sustainability and the holistic competency, together with the educational need to implement the SDGs in universities, led the authors of this article to develop a holistic and integrated approach using methodologies that enable addressing the complexity of current sustainability issues [29].

In accordance with the publication "Empowering educators for a sustainable future" [7], holistic approaches were sought to develop sustainable competencies. Pedagogical approaches need to facilitate the development of competencies and the methodologies applied must therefore be integrating. They cannot simply be limited to the transmission of knowledge. They have to engage the students in real-world activities achieving active participation.

Recent studies on sustainability education show that effective approaches tended to focus on the comprehensive view of a sustainability problem and its possible solutions [30, 31], for it enables students to put their ideas forward, integrate their knowledge, work together, make decisions and, on the whole, use their competencies [1, 4, 32]. Using those references as a starting point, two pedagogical approaches were selected and developed: Project-Oriented Learning (POL) and a Cross-disciplinary Workshop on Sustainable Food.

In small groups, the students had to develop a research project on a real problem related to the consumption aspect of SDG 12 in the field of sustainable food as a method to develop competencies in sustainability and the holistic competency. They worked on the projects in the subjects of Didactics of Mathematics (the weight of the project was 20% of the total mark of the subject), Didactics of Language and Literature (10%) and Didactics of Experimental Sciences (20%).

The students conducted the research projects on sustainable food for a period of two and a half months, using the POL methodology. All the research projects were presented to the university community on the day of the Cross-Disciplinary Workshop on Sustainability. Twenty experts in the subject, including lecturers from the university itself, lecturers from four other universities and experts from the Sustainability Department of Barcelona's City Council participated in the evaluation of the projects. All the evaluators had the same rubric of evaluation for the students and

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valued the following competencies: 1-They show interrelations between food and environmental, economic or social aspects; 2-They provide a realistic solution or proposal for the promotion of sustainable food; 3-They work cooperatively and responsibly; 4-They justify the results obtained and 5-They communicate well, both orally and in writing.

The integrated approaches of POL and the Cross-disciplinary Workshop on Sustainable Food (Figure 2), enabled working on and assessing sustainable competencies and the holistic competency together.

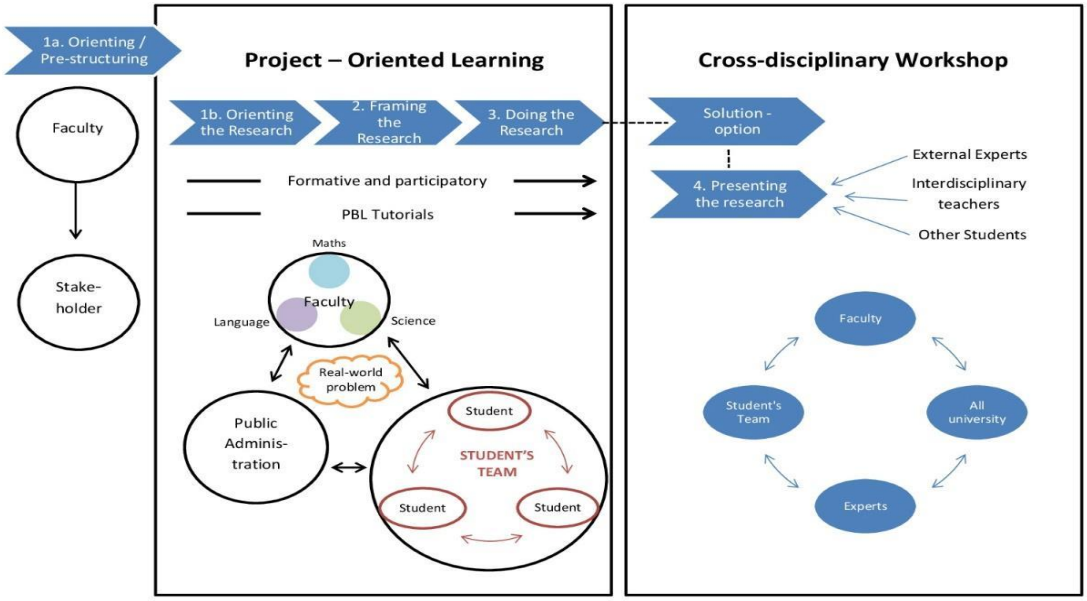

Figure 2. Methodological learning sequence for the development of Sustainable Competencies and the Holistic Competency. Source: Own work, inspired by Brundiers & Wiek, 2013.

2.2.1. Project-Oriented Learning (POL)

POL is an instructional methodology for active learning, in which students work together in small groups researching and solving real-world problems. Through POL, a shared co-creation process was performed in a learning environment that fostered research. This methodology is mentioned in the literature as an ideal tool to develop competencies in sustainability [30, 33, 34,35]. A recent study shows that POL is more effective than other methodologies to work in support of integrated approaches to sustainability [36].

Using POL, several groups of three to four students engaged in a research project related to sustainable food, which they presented to the rest of the university community at the Cross-disciplinary Workshop on Sustainable Food. After more than two months of research and interactive reflection, the students presented their research findings using a scientific poster or an interactive workshop to the rest of the university community. It encouraged addressing sustainable

food in a cross-disciplinary manner. After presenting their projects, they were evaluated by a group of experts.

2.2.2. Cross-disciplinary Workshop on Sustainable Food

A Cross-disciplinary Workshop on Sustainability is organised by the Sustainability Office of the *Universitat Internacional de Catalunya* every year. Its aim is for the university community to become aware of the importance of sustainability as an essential part of both education and preparation for the challenges of tomorrow. It encourages students and teachers to become part of the driving force for change towards a sustainable world. Teachers and students from different degree programmes can reflect on and share research projects in a common space. The topics addressed in the workshop during the past few years were related to one of the SDGs.

Information is provided through conferences, round tables, scientific workshops and posters to encourage reflection and a change of habits directed towards more sustainable behaviour. All the students can elaborate research projects related to the subjects addressed in the workshop and present their research results in the form of a workshop or scientific poster. The Workshop on Sustainability of academic year 2017-2018, was about sustainable food, related to SDG 12: sustainable consumption. Sustainable Food is also connected to SDG 3: good health and wellbeing and SDG 4: Quality Education. The concept of Sustainable Food enables working on and developing sustainable competencies using holistic approaches in a cross-disciplinary manner.

The objective of the ninth edition of the Cross-Disciplinary Workshop on Sustainability was to look at sustainable food and analyse the connection between healthy eating and protecting the planet.

Through student presentations and by listening to and talking to experts from different disciplines, issues such as: 'How does food waste relate to social justice? How is it that in 2017 there were 795 million people suffering from severe malnutrition? Is ecological agriculture sustainable? What is the relation between diet and climate change?' were explored.

The projects presented were the following: Does being vegetarian help to reduce the ecological footprint?; The overexploitation of fisheries; What if changing our diet saved the planet? Study on how the consumption of meat affects the planet; The ecological footprint of school dining rooms; Abandon ultra-processed foods: improve your health and sustainability and Cheap gold: palm oil and its impacts.

3. Results and Analysis

3.1. Results of the evaluation of sustainable competencies and holistic competency

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Table 1. Sustainable Competencies and the Holistic Competency (HC) evaluated by external experts

Maximum score	**0-2**	**0-2**	**0-2**	**0-2**	**0-2**	**TOTAL Qualification Students Research Project**
Sustainable Competencies and Holistic Competency (HC) evaluated by external experts	1	2	3	4	5	
TITLE OF THE PROJECT	Sustainable Competencies				HC	
1. Does being vegetarian help to reduce the ecological footprint?	1,58	1,33	1,80	1,33	1,33	**7,38**
2. The overexploitation of fisheries	1,58	1,47	1,42	1,42	1,25	**7,13**
3. What if changing our diet saved the planet? Study on how the consumption of meat affects the planet	2,00	1,92	2,00	2,00	1,75	**9,67**
4. The ecological footprint of school dining rooms	1,81	1,75	1,88	1,69	1,81	**8,94**
5. Abandon ultra-processed foods: improve your health and sustainability	1,75	1,92	1,92	2,00	2,00	**9,58**
6. Cheap gold: palm oil and its impacts	2,00	1,94	1,94	2,00	2,00	**9,88**

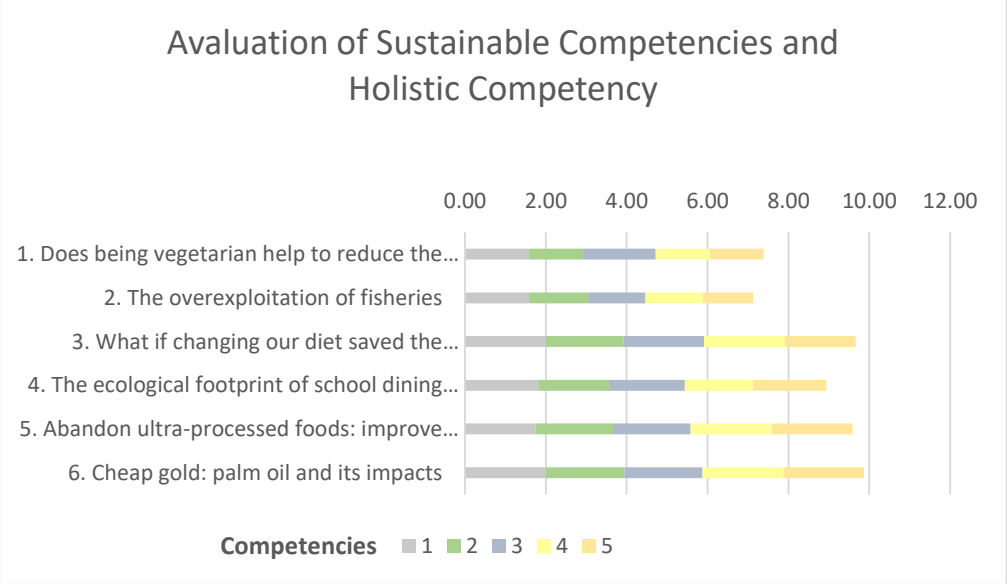

Figure 3. Results of the evaluation of Sustainable Competencies and the Holistic Competency

The experts' evaluation results of the students' competencies in sustainability and the holistic competency regarding the activity of the Cross-disciplinary Workshop on Sustainable Food were highly positive. According to the global results shown in Table 1 and Figure 3, all the groups developed competencies in sustainability and the holistic competency. The overall marks of the research projects presented by the students oscillate between 7,13 and 9,88 out of 10. According to the assessment performed by the experts, a good overall level of acquirement of the different competencies is observed.

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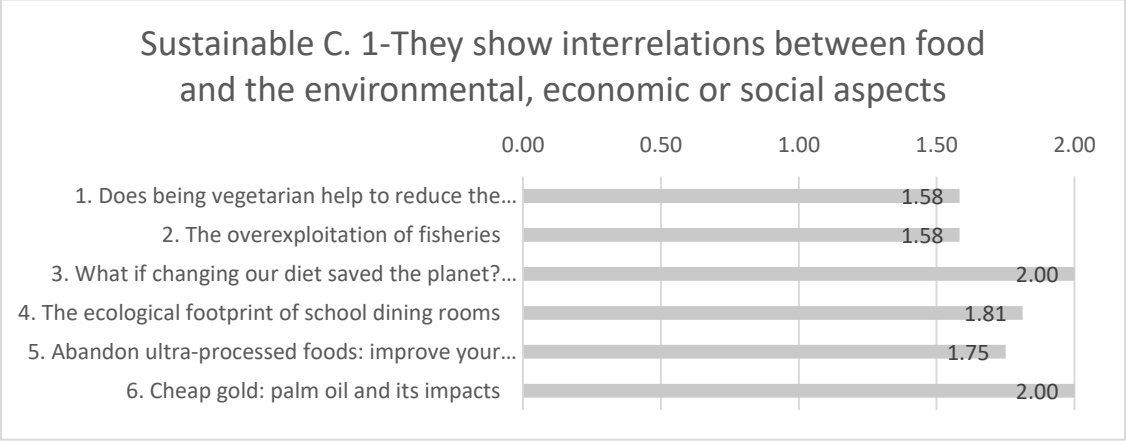

Figure 4. Evaluation results of Sustainable Competency: 1-They show interrelations between food and environmental, economic or social aspects

The results of each competency may be analysed separately. Sustainable Competency: 1-They show interrelations between food and environmental, economic or social aspects (SUST 1, adapted to the project on sustainable food) is the competency that obtains the best results. All the groups attained a *very good* command of the competency, reaching values between 1,58 and 2. The results may be due to the fact that, from the very beginning, students were encouraged to work on sustainability in an integrated manner connecting environmental, social and economic aspects. The questions initially raised by the students and which gave rise to the research project developed through POL linked two or more dimensions of sustainability. For instance, the group conducting research on palm oil wanted to know about the social and environmental impacts the current consumption of palm oil is causing and which everyday consumer products (detergent, toothpaste, biscuits, etc.) contain palm oil so as to promote alternatives that encourage more sustainable consumption.

The starting point of all the research projects was a real-word problem, the root cause of which was analysed.

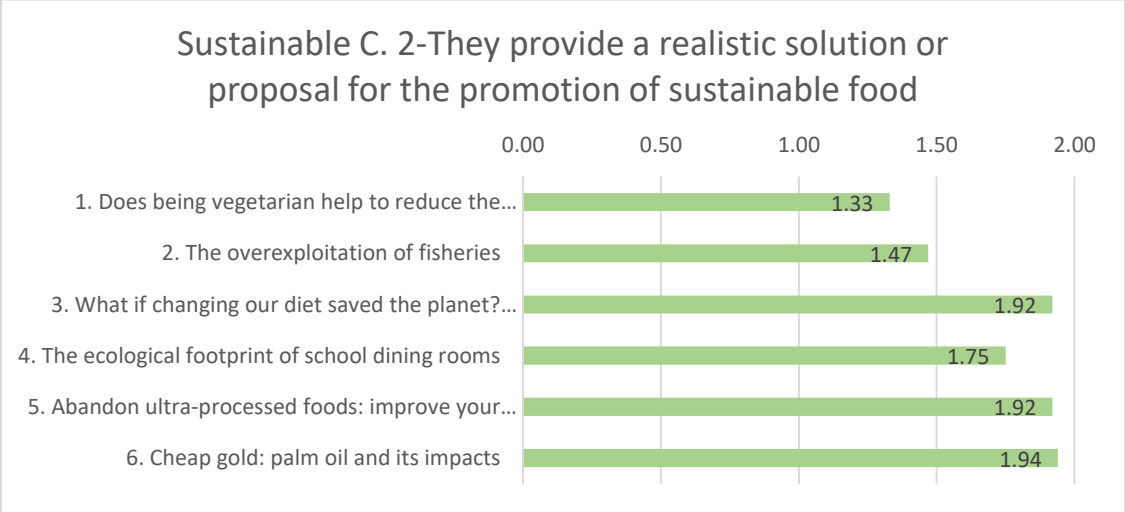

Figure 5. Evaluation results of Sustainable Competency: 2-They provide a realistic solution or proposal for the promotion of sustainable food

Sustainable Competency: 2-They provide a realistic solution or proposal for the promotion of sustainable food is an adaptation of SUST 2. The evaluation results of this competency (Figure 5) show two groups attained a *good* command of the competency (between 1,33 and 1,47) and four groups obtained a *very good* command (between 1,75 and 1,92). Two groups remained at the level of *good* command in a competency that strives to find realistic solutions to food problems. In this case, it means the students detected the problem –for instance, in the project of "overexploitation of fisheries"– but they did not present any workable solutions. They analysed what overfishing consisted in and studied the fish consumption habits of the university population, but failed to promote solutions related to eating for the problem of overfishing. In the conclusions of their project the students claimed that: "the overexploitation of fisheries is a growing phenomenon in society. The demand for fish has increased over time and it has been demonstrated that our consumption habits do not help redirect the situation." They condemned the problem, but failed to present viable solutions.

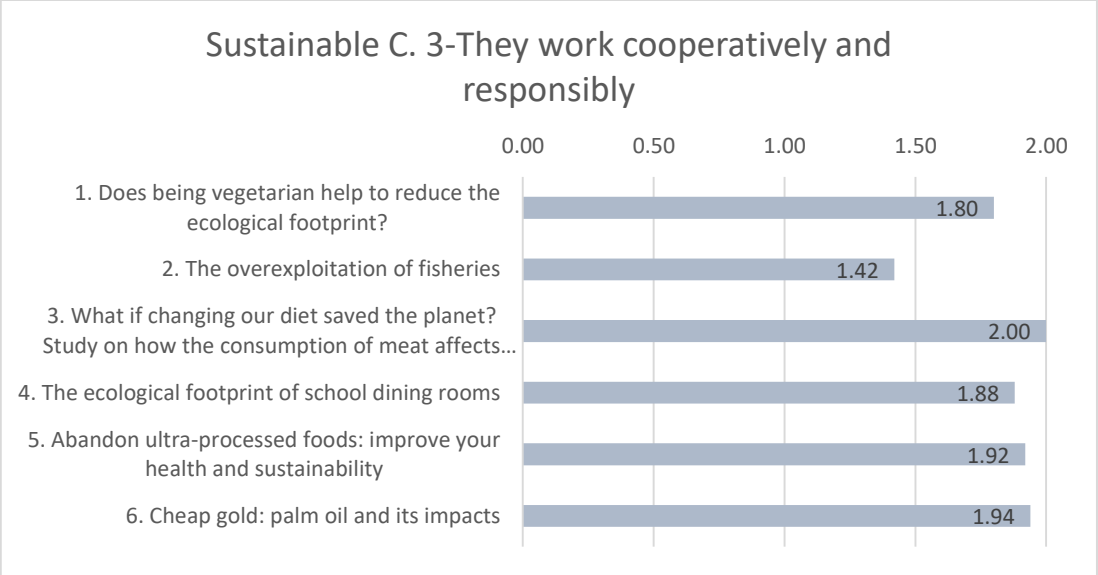

Figure 6. Evaluation results of Sustainable Competency: 3-They work cooperatively and responsibly

The evaluation results of Sustainable Competency: 3-They work cooperatively and responsibly, which correspond to SUST 3, show all the groups except one attained a *very good* command of the competency. During the work performed through POL for over two months and throughout the research presentations the students gave to the university community, it was observed that the members of the different groups shared the work equally and they worked well together. The intention of using POL was to promote teamwork, which requires dialogue and consensus in addition to the distribution of tasks. In view of the results, it may be inferred that the POL methodology is ideal for teamwork.

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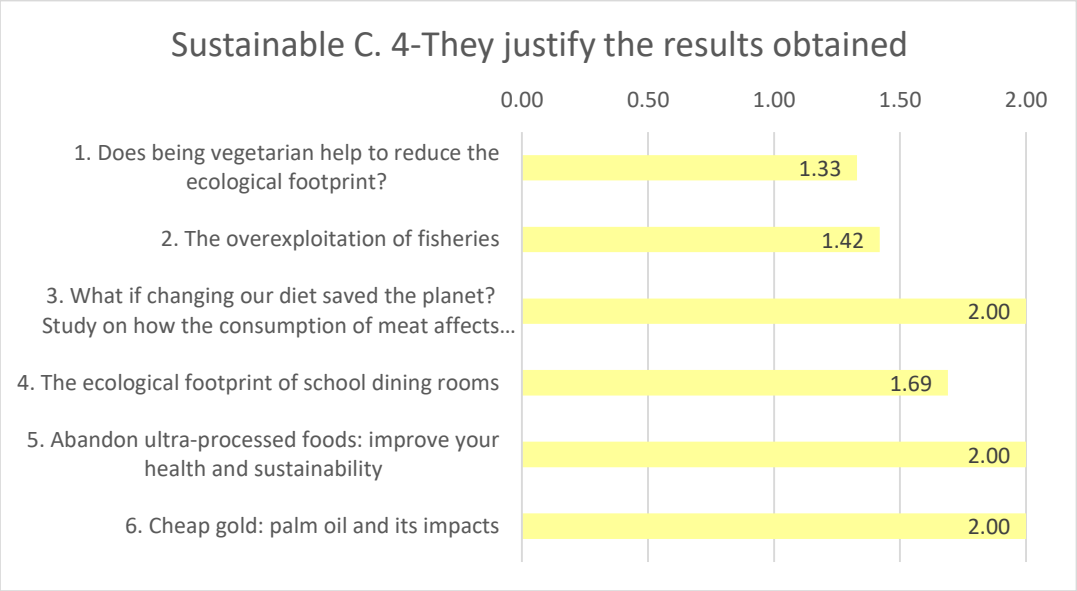

Figure 7. Evaluation results of Sustainable Competency: 4-They justify the results obtained

Figure 7 shows the evaluation results of Sustainable Competency: 4-They justify the results obtained, related to (though not exactly the same) SUST 4: Competency to apply ethical principles related to sustainability values in personal and professional behaviour.

By using POL, the students were encouraged to act ethically in their research and presentation of their findings. They were evaluated to see whether they were the real authors of the work presented (by checking for plagiarism) and whether the entire research process was rigorous. According to the results obtained, four groups reached a very good level and two groups attained a good level. The reason why not all groups obtained a very good level is not due to plagiarism, but to a lack of training in research and to not being able to sufficiently justify the findings obtained. These results show further training in research is necessary for university students.

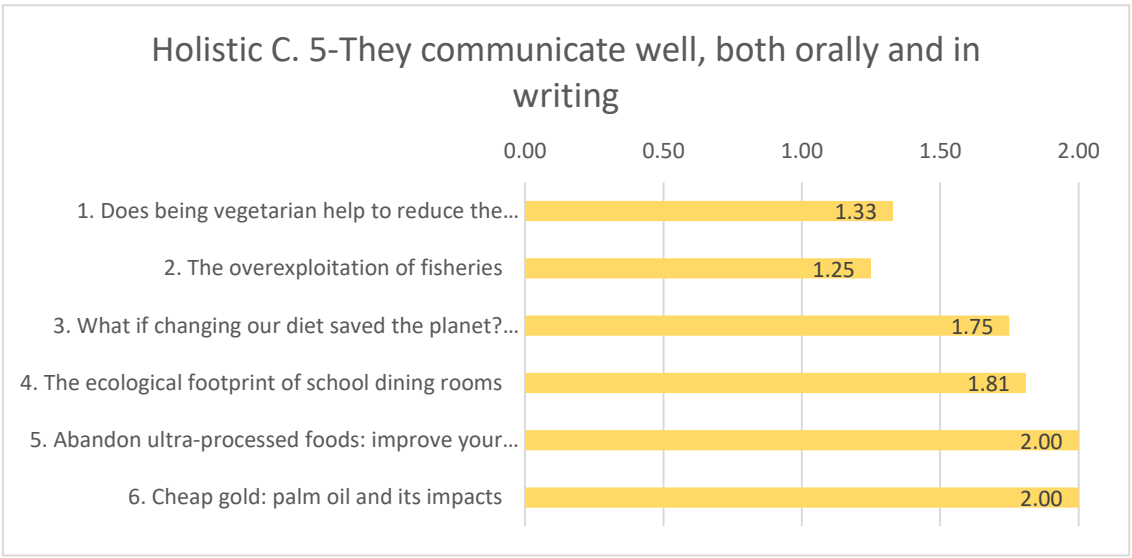

Figure 8. Evaluation results of the Holistic Competency: 5- They communicate well, both orally and in writing.

The results of evaluating Holistic Competency: 5- They communicate well, both orally and in writing (Figure 8) are very similar to the previous competency (Figure 7) because they are related to each other. When research is performed rigorously and justified conclusions are presented, it is common to communicate well, both orally and in writing.

In this educational experiment, Competency: 5- They communicate well, both orally and in writing, has been considered a holistic competency because, in oral or written communication, by presenting scientific posters, the students demonstrated whether there had been "Integrative thinking and practice", which is the indicator for holistic approaches in accordance with UNECE 2011 [6] (p. 7) and UNECE 2013 [7] (p. 15).

All these competencies were also assessed by the teachers of third year subjects in the degree of Primary Education, in which the research projects on sustainable food were developed to work on competencies in sustainability and the holistic competence. At the end of the entire process, each group of students had to present written work (written communication) that had to include all the sections of a scientific paper: title, abstract of the project (maximum 200 words); theoretical framework or introduction; objectives of the research project; research method; results and discussion; conclusions and bibliographic references (in accordance with the 6th edition of the APA Publication Manual). The length of the project, without including bibliographic references, had to be between 10 and 15 pages. The different teachers evaluated this written work separately using the assessment rubric described in Table 2 below.

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Table 2. Sustainability Competency and Holistic Competency evaluated by teachers of the faculty

Competences of sustainability evaluated by teacher fo the faculty	Sustainability Competency				Holistic Competency																**Writing Comunication. Average**	Cross-disciplinary Workshop on S. Food	Avaluation Final
	They show interrelations between food and environmental, economic or social aspects				The theoretical framework or introduction and the objectives are well elaborated. Correct research methodology				They justify the results obtained and use charts in an appropriate way				They communicate correctly in written form				Correct bibliography. Good quotations. They take care of the formal aspects of the figures, margins, etc.						
Maximum score	0-2				0-2				0-2				0-2				0-2						
subject of the Primary Education Degree	Maths	Langu	Scienc	Averag	Maths	Langu	Scienc	Avera	Maths	Langu	Scienc	Avera	Maths	Langu	Scienc	Avera	Maths	Langu	Scienc	Avera			
1. Does being vegetarian help to reduce the ecological footprint?	1,50	1,50	1,50	1,50	1,00	1,50	1,50	1,33	0,75	1,00	1,00	0,92	0,75	2,00	1,00	1,25	0,50	1,00	1,00	0,83	**5,83**	7,38	6,61
2. The overexploitation of fisheries	1,75	1,50	1,50	1,58	1,50	1,00	1,00	1,17	1,00	1,00	1,00	1,00	1,50	1,75	1,00	1,42	1,75	1,50	0,50	1,25	**6,42**	7,13	6,77
3. What if changing our diet saved the planet? Study on how the consumption of	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	1,75	2,00	2,00	1,92	2,00	2,00	1,20	1,73	2,00	1,75	1,20	1,65	**9,3**	9,67	9,49
4. The ecological footprint of school dining	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	1,50	1,50	1,50	1,50	1,75	1,75	1,50	1,67	0,50	1,00	1,00	0,83	**8**	8,94	8,47
5. Abandon ultra-processed foods: improve your health and sustainability	2,00	2,00	2,00	2,00	1,50	2,00	2,00	1,83	1,50	2,00	2,00	1,83	1,50	2,00	1,50	1,67	1,50	1,75	1,50	1,58	**8,92**	9,58	9,25
6. Cheap gold: palm oil and its impacts	2,00	2,00	2,00	2,00	1,50	2,00	2,00	1,83	2,00	2,00	2,00	2,00	2,00	2,00	1,20	1,73	1,75	1,75	1,25	1,58	**9,15**	9,88	9,52

This rubric allowed assessing competency in sustainability 1 and the holistic competence by means of different indicators such as: The theoretical framework or introduction and the objectives are well elaborated; Correct research methodology; They justify the results obtained and use charts in an appropriate way; They communicate correctly in written form and Correct bibliography. Good quotations. They take care of the formal aspects of the figures, margins, etc.

As shown in Table 2, the overall results of the written projects assessed by the teachers of the subjects are all slightly inferior to the same projects presented orally the day of the Cross-disciplinary Workshop on Sustainability assessed by the external experts. This difference in overall results is due to the fact that the competencies evaluated were not the same and they did not have the same weight. In the Cross-disciplinary Workshop on Sustainability, the four competencies in sustainability weighed 80%, while the weight of the holistic competence was 20%. In the assessment of the written projects, the weight of the competencies was inverted. The competency in sustainability was worth 20% and the holistic competence, assessed by means of four indicators, was worth 80%.

The results of these two kinds of competencies may be analysed separately. When the teachers of the subjects assessed the competency in sustainability, the results were slightly superior to the assessment performed by the external experts (Table 2, first column and Figure 4). Despite the fact that when the external experts evaluated the different competencies on sustainability, Sustainable Competency: 1-They show interrelations between food and the environmental, economic or social aspects obtained the best results. The results show that when the students are assessed on a more continuous basis (having more time to prepare and gathering more information), they attain a higher command of the competency. When assessed by the teachers of the subject, all the students had a *very good* command of the competency in sustainability, and four groups obtained the highest possible score.

With respect to the assessment results of the holistic competency on behalf of the teachers of the subjects (Figure 9), it was observed that three groups of students attained a *good* command and the other three groups a *very good* command, without any group achieving the highest possible score.

Peer-reviewed version available at Sustainability 2018, 10, 3698; doi:10.3390/su10103698

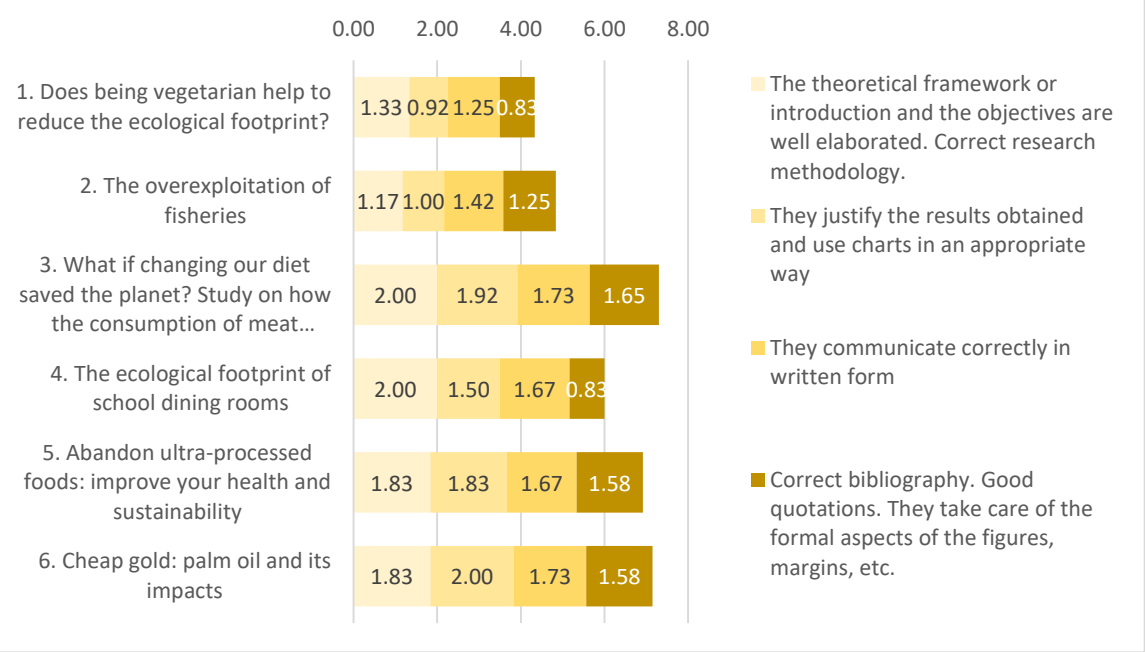

Figure 9. Evaluation results of the holistic competency by the teachers (written communication)

The fact that the marks of the written work are slightly lower than those of the oral presentations given at the Cross-disciplinary Workshop may be due to a number of reasons. It is obvious that a project defended in 15 minutes may not be assessed in the same manner as a 10-15 page written research project that took the students two and a half months to elaborate and complete. The teachers who evaluated the written work carried out a follow-up of the students during that period of time. Assessing the oral presentations was fast, while correcting the written projects took more time and was much more thorough. As mentioned earlier, the weight of the competencies in sustainability and the holistic competence was inverted in the two assessments performed.

4. Discussion

In view of the results, it may be said that the objectives this study aimed to reach through the experimental educational model used have been achieved. Two research questions were posed: 1) What teaching methodologies are suitable for the development of competencies in sustainability for the students? and 2) Are these methodologies suitable for empowering students to be the protagonists of the implementation of the SDGs in the university they study at?

The results shown in Figure 3 and Tables 1-2 show what several authors affirm [7, 29, 37, 38, 39, 40, 41, 42], that when holistic and integrative approaches are used, students develop competencies in sustainability in a favourable manner. In this study, the Methodological Learning Sequence (Figure 2) was used as a tool to develop sustainable competencies [4, 22]. If the methods used had merely been expositive, based solely on the transmission of knowledge, it would not have been possible to develop competencies in sustainability [9, 38], let alone attaining a very good command of those competencies [27].

POL, the Cross-disciplinary Workshop and the presentation of the written project enabled developing Sustainable Competency 1: They show interrelations between food and environmental, economic or social aspects. In accordance with [1, 25], sustainability needs to be addressed in an integrating manner, which is reflected in the formulation of this competency. Understanding this integrated vision of sustainability is possible when addressing real-world problems [34, 41, 43] that need to be solved. If students are not encouraged to think and act, it is hard for them to interrelate environmental, economic and social aspects and to identify the impact of their daily actions [13].

As POL is a methodology that focuses on students working in small groups trying to solve real problems [34], it facilitated the development of Sustainable Competency 2: They provide a realistic solution or proposal for the promotion of sustainable food. It has also contributed to a "holistic approach to envisioning change and thereby achieving transformation" [7 recording 6] (p. 6).

The different stages of the methodological sequence, as they are active pedagogical approaches [36, 44], also contributed to the development of competencies 3 and 4: "work cooperatively and responsibly" and "justify the results obtained". It is confirmed that, for individuals to understand complex world problems, they need to collaborate with each other [34].

Considering the results of this study and in accordance with [33, 34, 35, 36], it may be said that POL is a particularly appropriate methodology to develop competencies in sustainability. It has enabled training students in the research of sustainable development [45]. According to Brundiers and Wiek (2013) [30], POL offers an innovative approach to partnerships between the university and external organisations. In our experimental educational programme, the students interacted with external stakeholders and with public administration employees from the Sustainability Department in Barcelona's City Council (Figure 2).

In answer to the first research question, the results obtained (Figure 3 and Tables 1-2) confirm these activities or any other similar activities, as long as they concern active and holistic teaching methodologies, are suitable for the development of competencies in sustainability for the students [34, 36, 46, 47].

Furthermore, as stated in the second question, this study intended to demonstrate the empowerment of students to be leaders in the implementation of the SDGs in the university. The Cross-disciplinary Workshop was used a tool to address SDG 12 which regards sustainable consumption. The report "Getting started with the SDGs in universities: A guide for universities, higher education institutions, and the academic sector" [45], recommends universities to hold a half to full day "Cross-university SDG workshop" to work on a particular aspect of sustainability within the university community [45]. This recommendation was put into practice at the Cross-disciplinary workshop on Sustainable Food. The students took centre stage when defending their research projects to external experts, teachers from other faculties and students from different degree programmes, thus driving positive change within the university context [7, 24]. The Cross-disciplinary Workshop on Sustainable Food provided the students with the necessary knowledge, skills and motivation to understand and address SDG 12 with regard to food. It

empowered and mobilised young people, future teachers in this case. The university's public engagement and participation in addressing SDG 12 are thus strengthened [45].

The Cross-disciplinary Workshop on Sustainable Food, in addition to being a tool to develop and assess students' competencies in sustainability using holistic and integrated approaches [11, 32], has enabled working on sustainability in a cross-curricular manner in the university [1], empowering youth in achieving sustainable food consumption (SDG 12).

5. Conclusions and Outlook

The scientific value of this article lies in the provision of several examples of POL approaches and the Cross-disciplinary Workshop on Sustainability. It is demonstrated they are appropriate tools for developing sustainable competencies and the holistic competency in pre-service teacher training. This paper allows other educators to replicate these approaches in other contexts.

The analysis of the results obtained in the assessment of the competencies revealed the students acquired the necessary competencies. A practical case of integrating sustainability into the curriculum from a holistic viewpoint was also shown.

It has been shown how POL is an appropriate tool for teaching and learning in an interactive learner-centred manner, enabling exploratory, action-oriented and transformative learning [44]. It is confirmed that POL enables the favourable development of competencies in sustainability and the holistic competence.

This study has also shown that the Cross-disciplinary Workshop on Sustainability enables empowerment and mobilization of students in the implementation of the SDGs in the university.

One limitation of the study was the lack of a control group. It would also be interesting to develop holistic approaches over a longer period of time.

As no definition of the holistic competence was found in the literature related to Sustainable Development in Education (SDE), but recommendations appear on how to work on competencies in sustainability in teacher training using holistic approaches, it was considered appropriate to analyse the holistic competence by means of several indicators, despite the limitations this implied. Further research is necessary to determine how holistic approaches can be addressed in teacher training.

Author Contributions: Conceptualization, Albareda-Tiana, S., Vidal-Raméntol, S., Pujol-Valls, M. and Fernández-Morilla, M; Methodology, Albareda-Tiana, S. and Fernández-Morilla, M.; Validation, Albareda-Tiana, S. and Fernández-Morilla, M.; Formal Analysis, Albareda-Tiana, S. and Fernández-Morilla, M.; Investigation, Albareda-Tiana, S. and Fernández-Morilla, M.; Resources, Albareda-Tiana, S., Vidal-Raméntol, S., Pujol-Valls, M. and Fernández-Morilla, M.; Data Curation, Albareda-Tiana, S. and Fernández-Morilla, M.; Writing-Original Draft Preparation, Albareda-Tiana, S.; Writing-Review & Editing, Fernández-Morilla, M. and Pujol-Valls, M.; Visualization, Albareda-Tiana, S.; Project Administration, Albareda-Tiana, S.; Funding Acquisition, Albareda-Tiana, S., Fernández-Morilla, M., Pujol-Valls and Vidal-Raméntol,S.

Funding: This research was funded by the government of Catalonia in the call for the ARMIF 2015 project "Global plan of integrating mathematical, scientific and linguistic competencies in pre-service teacher training" [Ref. 2015 ARMIF 00044] and the EDINSOST Project "Education and Social Innovation for Sustainability. Training at Spanish universities of professionals as agents of change to face the challenges of society", funded by the "R&D State programme oriented towards the challenges facing society" of the Spanish Ministry of Economy and Finance [Ref. EDU 2015-65574-R].

Acknowledgments
We would like to thank to Ann Swinnen for the feedback and comments on an earlier version of this article. The authors gratefully acknowledge the support of the Integral Sustainability and Education (SEI) Research Group of the *Universitat Internacional de Catalunya* (2017 SGR 119).
Conflicts of Interest: The authors declare no conflict of interest.

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