

Relationship Dependence of Mathematical Applications to the Economy and Sustainable Developmental Goals

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Abstract

Higher education must include training in sustainability to make all actors aware of the serious problems our planet is facing. Mathematics plays an important role in the achievement of the Sustainable Development Goals (SDG) and at the same time these allow working with real situations in the subject of mathematics, providing the student with active learning. Sustainability is used to make the student see the usefulness of mathematics while instilling values and attitudes towards it. A set of problems have been raised during the academic year that are solved with the developed mathematical techniques, and through a survey, the students' perceptions about the usefulness of mathematics to reach the goals established in the SDG has been evaluated. The results show that, regardless of the student's gender, the student's assessment of the usefulness of this subject in solving real problems improved. It has been observed that this teaching methodology has helped to motivate students and even those who do not like this subject have improved their appreciation of it.

Keywords: mathematics; higher studies; sustainability; Sustainable Development Goals; motivation

1. Introduction

The Brundtland report defines sustainability as “the ability to meet the needs of the present without compromising the ability of the future generations to meet their own needs” [1]. Sustainability has three dimensions: economic, environmental and social. Development is only sustainable if concepts related to economic viability, social justice and environmental impacts are addressed [2].

The importance of education to achieve sustainable development is increasing. In 2005, the Decade of Education for Sustainable Development 2005–2014 was signed, and in 2015, the United Nations approved Agenda 2030 which set out 17 Goals for Sustainable Development (SDGs), with the aims of ending poverty, promoting quality education, achieving gender equality and sustainable cities and communities, among other goals.

Universities play a key role in moving towards sustainability in the context of education. The institutions should lead the sustainability movement by providing appropriate content to students and developing knowledge. In this sense, it is necessary to establish changes in curricula and generate training actions that reorganize programs and competences considering sustainable criteria [3,4,5,6,7,8,9,10,11,12,13]. The aim is to transform knowledge in education for sustainable development into critical systemic thinking and action [14,15].

Lozano, Barreiro-Gen, Lozano and Sammalisto [16] report that there has been a breakthrough in incorporating sustainability skills into higher education. However, they show that the social dimension is less addressed than the economic and environmental dimensions, and provide a perspective on how to better develop and incorporate sustainable development competences in the classroom. In this line, works such as [17] have described the factors that have driven the academic and operational sustainability objectives at the Okanagan campus of the University of British Columbia, while, recently, [18] have described the need for universities to adapt to industry 4.0 through sustainable education.

A new style of teaching must be offered [19,20] that leads to students acquiring the necessary sustainability skills [21,22,23]. This transformation of learning requires the commitment of teachers [24]. In higher education institutions there is often no institutional support for integrating sustainable development into their activities [25], and most efforts are focused mainly on committed academics [15,26].

There are works that document the introduction of sustainability in subjects such as science or language teaching [27,28]. However, there is little research that investigates the fundamental role of mathematical education of students to achieve sustainable development.

Zehetmeier and Krainer [29] present ways to promote sustainability in the curriculum among mathematics teachers. Cardeñoso, Azácate and Oliva [30] use a sample of students who were studying for the Master's Degree in Teacher Training in Secondary School, in the specialties of mathematics, physics and chemistry, and biology and geology, to find out about their understanding of and approach to sustainability. The authors conclude that students in the speciality of mathematics (future teachers of this area) are less aware of sustainability, as opposed to those in biology and geology, who are more predisposed to this subject. Calabuig, Alsina and Geli [31] set out the profile that a teacher of the subject of mathematics should have in accordance with education for sustainability. Joutsenlahti and Perkkilä [32] explain sustainable development in mathematics education from the point of view of teacher training. Alsina and Mulà [33] identify the elements that make it possible to teach in the professional practice of mathematics through experiences based on reflective learning and education for sustainability.

Vásquez, Seckel and Alsina [34] investigated the competencies for incorporating education for sustainable development in the classroom, specifically, in the mathematics classes of future Chilean teachers of early childhood education and primary education. The results show that most teachers link them to environmental education, but only 4.6% of primary school teachers link them to environmental, social and economic issues. They conclude that teachers are aware of the importance of mathematics education in achieving sustainable development, but only point out general ideas on how to incorporate it into the classroom.

It is necessary to start from the general culture of the student to achieve sustainability from mathematics [31]. It is important to work on mathematics from a global and interdisciplinary perspective in order to achieve this objective. Alsina and Calabuig [35] determined the importance of students establishing a relationship with the environment based on mathematics.

Sometimes students do not understand the usefulness of mathematics and some even consider it to be a complicated subject, which already predisposes them to it. As [36] point out in a study of 297 students in several senior secondary schools in Ghana, students often have a positive perception of mathematics because they think it is used in everyday life, but they consider it difficult. On the other hand, some see mathematics as an isolated set of procedures with no real-life applications [37], which discourages them from learning. Innovative practices that provide them with a positive experience could help improve their performance in mathematics and the perception of its usefulness [38]. Therefore, the activities carried out by the teacher in the classroom are very important to motivate students in this subject and to obtain their maximum potential [39,40,41].

If students considered mathematics as a useful means of solving everyday problems, this approach could be extended to solving wider problems, such as those involving the planet. However, how could sustainability skills be introduced into this subject alongside the learning of new mathematical techniques in higher education?

To answer this question, the aim of this paper is to relate mathematical teaching to real problem solving focused on SDGs and to assess whether students are stimulated by the teaching of this subject. This teaching innovation makes it possible to attract students' attention to mathematical techniques when solving current problems that affect their more or less immediate environment.

2. Materials and Methods

The teaching experience presented in this work has been carried out with students from higher education, specifically from the degree in economics from the Faculty of Economics and Business of the University of Murcia (Spain). In this degree there are several subjects with mathematical content distributed in the four years that the degree lasts. The action described has been carried out in the subject of mathematics for economics in the second year, whose program includes optimization techniques. Students enrolled in this course already have sufficient capacity and knowledge to address the problems involved in the goals of the SDGs.

In order to promote the students' skills and attitude towards the study of mathematics, a set of practical questions have been proposed that relate real problems to the contents developed in the mathematics for economics

subject. To this end, after explaining the theory, the activities carried out to improve the understanding of these concepts involve some of the goals of the different SDGs.

There are different exercises that can be proposed, each of them related to a different SDG in [Table 1](#). In this way, the student, through the instrumental subject of mathematics, will have deepened understanding of issues related to sustainable development and will be able to become aware of the situation of our planet. As an example, in the following section, some of the exercises analyzed in class involving several SDGs are presented.

Table 1. Mathematics for sustainable development.

In order to know if with these exercises we have achieved the double objective that they know the SDGs and learn mathematics with pleasure, at the beginning of the course they were given a survey). They were asked about their level of knowledge of the SDGs and the usefulness that, according to them, mathematics would have in helping to achieve these objectives. During the course, practical exercises on the SDGs were proposed and at the end of the course, the survey was passed back to them, with the question about the usefulness of mathematics and the degree of motivation achieved. The survey was anonymous and each student was assigned a code that only he or she knew, which he or she had to specify in each of the questionnaires. In this way we have samples related to the results before and after the activities.

These practices were carried out in the second term of the 2019–2020 academic year and 180 students were enrolled in the subject. In the initial survey 165 students participated and in the final survey 161, with 160 students completing both surveys; of which 75 were men (45.5%) and 90 women (55.5%), aged between 19 and 22.

2.1. Practical Application of Mathematics in the Development of SDGs

To illustrate how to introduce mathematics in the development of the SDGs, two application examples are presented, one for Goal 2 and another one for Goal 12.

Goal 2, “Zero hunger”, has among its targets to end hunger and ensure access to safe, nutritious and sufficient food for all people, year round, and to end all forms of malnutrition, ensuring the sustainability of food production systems. We need to be aware that extreme hunger and malnutrition are an impediment to sustainable development and it is in our hands to understand this situation and to address it.

Goal 12: Responsible production and consumption, states the aim: “To do more and better with fewer resources, increasing the net welfare gains from economic activities by reducing resource use, degradation and pollution throughout the life cycle, while achieving a better quality of life”. A pressing problem today is the emission of polluting gases into the atmosphere and the need to reduce them by minimizing the cost of transporting goods is therefore analyzed.

Once the goals of these two SDGs are known, exercises are proposed, which also serve to apply mathematical techniques developed in class.

2.1.1. SDG2 Approach Exercise

The NGO ActionAid produces the annual Global Hunger Index. According to this indicator, there are five countries in the world where many of their citizens are undernourished, a large percentage of children are underweight for their height or stunted, reflecting chronic malnutrition, or worse, die before their fifth birthday. The Central African Republic leads the way, followed by Yemen, Chad, Madagascar and Zambia.

In the Central African Republic, almost half of its children are stunted and 60% of the population is undernourished. By 2019, more than half the population was in need of humanitarian assistance due to the security problems faced by the agencies responsible for providing it. A new report by the Food and Agriculture Organization (FAO) and the World Food Programme warned that half the population is suffering from hunger. The consequences of violence and massive population displacement have resulted in poor harvests and very high prices even for basic foodstuffs.

ActionAid is developing different projects to eradicate the hunger that thousands of people suffer every day. Through various international aid programs, funds have been obtained to provide various basic foods (milk, meat, cereals, rice and fruit) for a daily diet of at least 1800 calories, 24 g of protein and 750 mg of calcium. For each 100 g food ration, there is nutritional and unit cost information in euros, as shown in [Table 2](#). The optimum diet must be found that has the lowest associated cost and allows all the above requirements to be met.

Table 2. Basic data of the Sustainable Development Goal 2 (SDG 2) problem.

To solve this problem, we defined the variables involved in it. Thus we have: x_1 is the number of daily rations

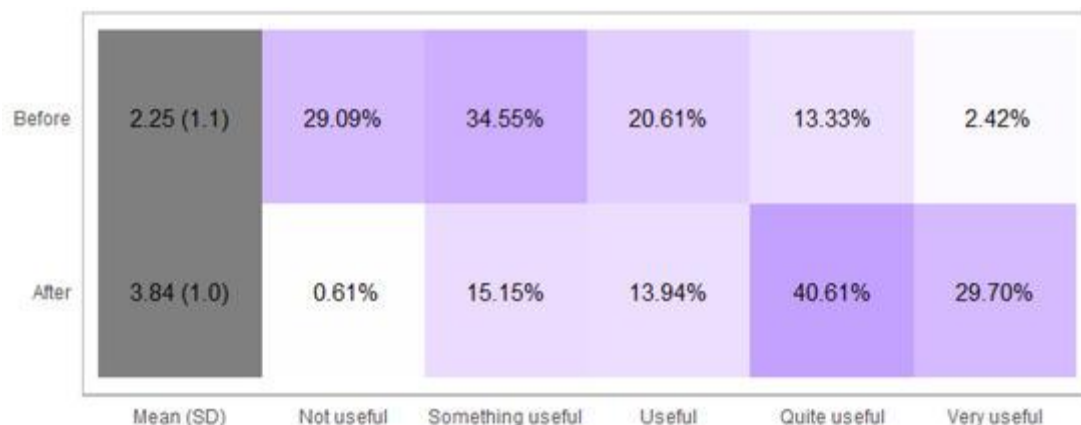


Figure 1. Perception of the usefulness of mathematics for the achievement of SDGs before and after the exercises.

In order to better observe the change that took place in the students' attitudes towards the mathematics subject after the internship, the density figure of the assessment of the utility of mathematics for the achievement of the SDGs before and after the internship is shown (**Figure 2**). The vertical lines show the average in each case. Initially, the assessments were very low (asymmetry on the right) and later they increased considerably (asymmetry on the left).

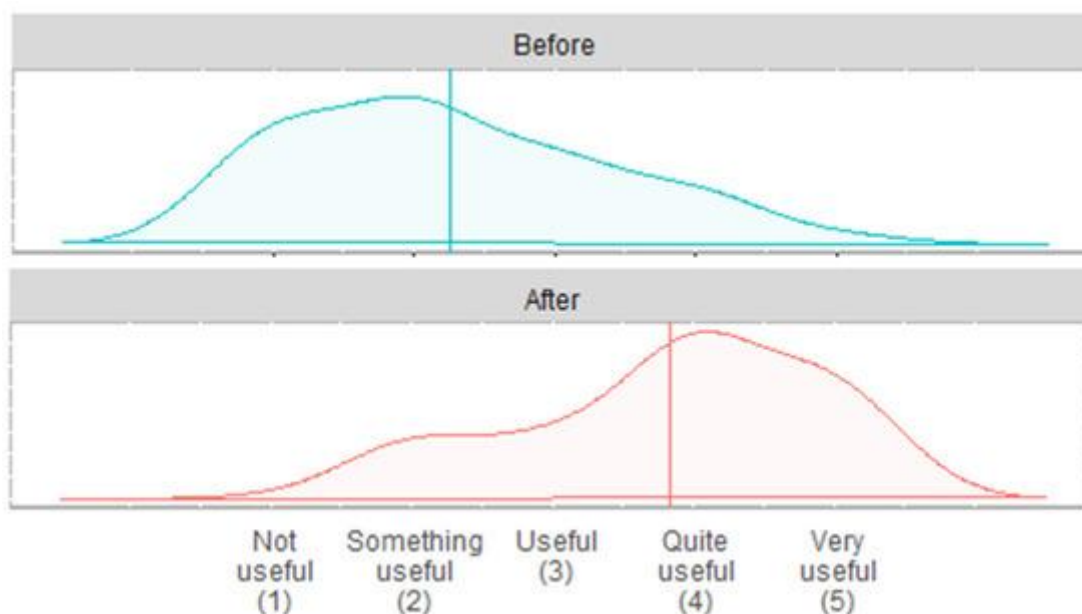


Figure 2. Visualization that treats the Likert items (usefulness before and after the exercises) as a continuous variable.

As can be seen in **Table 5**, the perceived usefulness of mathematics increased considerably after the exercises. Thus, those students (48) who stated at the beginning of the term that their perception of the usefulness of this subject for the achievement of the SDGs was 1 (i.e., not useful at all for them), in the new scenario, after completing the exercises, had an average score of 3.42 (quite useful) with a deviation of approximately 1 point. The same is true for the other ratings.

Table 5. Average rating of the usefulness of mathematics after the completion of the exercises.

When differentiating by sex it has been verified that there were no significant differences (p -value = 0.733) in the students' perceptions once the exercises had been carried out: 30% of women and 29.3% of men valued the usefulness of the subject very highly, compared to 1.1% and 4%, respectively, at the beginning of the four-month period (**Table 6**).

Table 6. Distribution by sex of the perception of the usefulness of mathematics.

This perception of usefulness changed from one scenario to another if one considered that mathematics was or was not an attractive subject for students. The average utility varied among those who did like the subject from

2.35 to 4.24, while among those who did not like it, it increased from 2.07 to 3.04, on average. Distinguishing by sex (Figure 3), the differences in mean scores were not statistically significant before the exercises, however, after the exercises, those students who stated that they liked mathematics had, on average, considerably increased their perception of the usefulness of mathematics, both men and women.

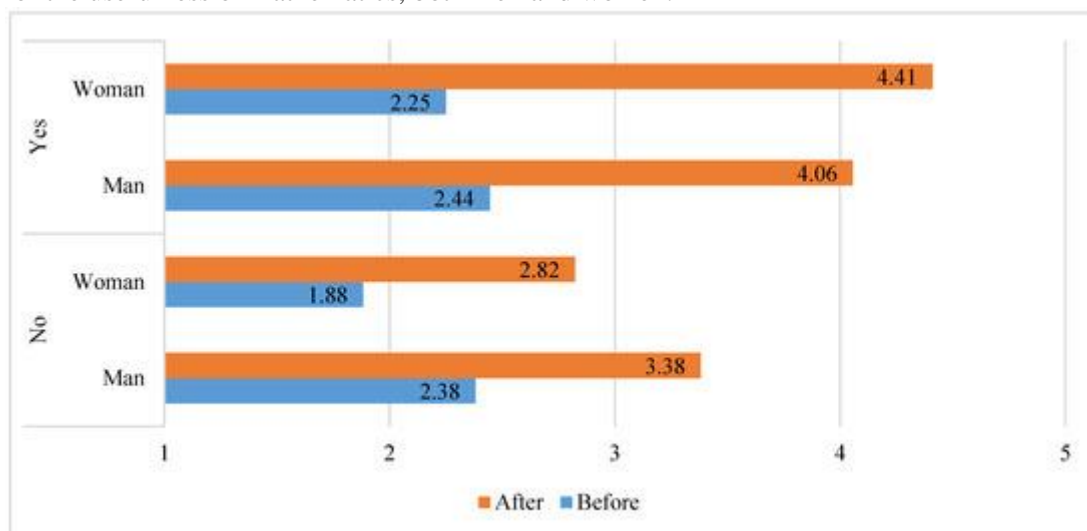


Figure 3. Distribution of the perception of the usefulness of mathematics according to subject likes and dislikes and gender.

In order to know if these activities adapted to the real world, and solving exercises related to the SDGs made the students feel motivated regarding the teaching of mathematics, a question was included in the final questionnaire where this aspect is reflected. It has been observed that 75% of the students have been highly motivated in the mathematics class with these exercises, even 60% of those who do not like this subject have improved their perception of it.

4. Discussion and Conclusions

Mathematics is a key subject in the quantitative grades, particularly in those taught in the Faculty of Economics and Business of the University of Murcia. It is essential to understand that mathematics solves everyday problems and that it provides a very valid tool when facing reality. In this subject, mathematical concepts and procedures can be related to real situations. Students must be given a global vision, for the development of which it is necessary to collaborate with teachers of other subjects. Interdisciplinarity is fundamental in this whole process.

The teacher has the obligation to transmit the mathematical content that allows the student to acquire the necessary skills to understand the concepts related to sustainability and the aspects of the world around them. It is important that they acquire a new way of understanding the world and that they have innovative tools that allow them to solve the problems that arise. Problems of all kinds can be found in the great global challenge that we have in view of 2030, such as the achievement of the goals set out in Agenda 2030, approved by the General Assembly of the United Nations. Teachers can solve mathematical problems that involve a social, economic and environmental commitment, showing the links between this subject and sustainability.

A set of practices has been designed from the mathematics subject of the degree in economics at the University of Murcia to respond to the issue of sustainability. The students can apply their mathematical knowledge in the resolution of real problems, sustainability being the main focus. This subject revolves around the mathematical optimization of problems with equality and inequality restrictions, which are very valid tools to solve real problems related to the SDGs. Through different exercises they learn to give answers to real problems using mathematics and generating greater satisfaction by understanding the world around them.

The perception of the usefulness of these exercises has been measured through two questionnaires. The first was taken at the beginning of the term and the second at the end of the course. It was found that, regardless of the student's gender, their perception of how the subject matter can influence the resolution of problems associated with SDGs increased greatly.

More than 70% of the students stated that this way of working with mathematical optimization was useful or

very useful for the achievement of the designed problems, against 16% who thought the same before this teaching innovation.

This set of exercises has also helped us to improve the perception of the usefulness of mathematics by students who, at the beginning of the year, said that they did not like it. They have now discovered a range of possibilities for making the planet more sustainable and are more motivated by the development of classes in this subject.

This active methodology focuses on the development of critical thinking. It is possible to observe the usefulness of mathematical concepts to concrete problems, stimulating and favoring the interest towards the subject. Furthermore, it is a good starting point for introducing sustainability into the university world, not only from the environmental sphere. Students must be aware that they are the agents of change so that this society can improve and what is dictated by the United Nations can become a reality by 2030.

Knowing the usefulness of this educational innovation, it will be reintroduced in a new academic year along with a broader survey that will provide details on the effectiveness of using these activities at the university to improve student achievement in mathematics classes and academic effectiveness.

Author Contributions

Conceptualization, J.C.-F.; methodology M.L.-L., J.C.-F. and Ú.F.-M.; investigation, M.L.-L. and Ú.F.-M.; formal analysis, Ú.F.-M. and M.L.-L.; supervision, M.L.-L., J.C.-F. and Ú.F.-M.; writing—review and editing, M.L.-L., J.C.-F. and Ú.F.-M. All authors have read and agreed to the published version of the manuscript.

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