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Integrating Energy and Sustainability into the Educational Curriculum: A Pathway to Achieving SDGs

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Abstract: This study provides a comprehensive assessment of how the concept of energy is addressed in secondary and baccalaureate curricula in Spain, with a focus on alignment with the Sustainable Development Goals (SDGs) and the promotion of sustainable development. Through a qualitative analysis of recent educational legislation, the research highlights the integration and contextualization of energy in different knowledge domains to promote understanding of current environmental challenges. Using a mixed methodology, the study examines curricular references to energy and categorizes them according to their emphasis on energy sources, consumption, technology, ethical awareness, and sustainability. The findings reveal a significant presence of the topic of energy, highlighting efforts to align educational curricula with the SDGs. Despite the significant focus on energy, the study identifies areas for improvement, including the need for greater interdisciplinary and practical integration that equips students to address energy challenges in innovative and sustainable ways.

Keywords: educational regulations; sustainable development; energy concept; curriculum analysis

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1. Introduction

Over the past decade, there has been a significant increase in the focus on Education for Sustainable Development (ESD) at all levels of education in Spain. This upsurge is part of a broader global movement to incorporate the principles of sustainability into educational frameworks, a shift recognized and promoted by numerous international bodies [1–5]. The declaration of the Decade of Education for Sustainable Development (2005–2014) [6] sparked an increase in political and social efforts to raise awareness of pressing issues such as climate change, economic stability, and social justice for future generations. This drive has galvanized researchers and educators alike, leading to a concerted push to integrate ESD into both the standard curriculum and mandatory education [5,7] from the earliest years [8], with particular attention paid to higher education levels [9].

Since 2015, the concept of sustainability has been at the forefront of global dialogues and education forums [10], with the direct aim of achieving the Sustainable Development Goals (SDGs). In the same year, Spain committed to updating its education legislation in line with Organic Law 8/2013, known as the Law for the Improvement of the Quality of Education (LOMCE) [11], which set a clear path for the integration of the SDGs into the national education framework. This commitment paved the way for the introduction of Education for Sustainable Development (ESD) as a cornerstone of innovation in the revision of the Organic Law on Education (LOMLOE) [12], moving forward despite potential political and ideological hurdles. The formal incorporation of the SDGs from the 2030 Agenda into Spanish education policy took effect on 1 January 2016, marking a significant step toward integrating these global goals into school curricula through well-defined plans and initiatives. However, despite these legislative advances, we find ourselves in a world

that is increasingly preoccupied with personal achievement, often at the expense of broader societal gains [13]. While the past two decades have seen notable advances and insights in the field of sustainability education, these efforts have yet to catalyze the profound changes needed to address the growing challenges of our time [14,15]. Issues such as the unequal distribution of global resources, a prevailing culture of disposability, the overuse of nonrecyclable materials, the loss of fertile land, and the looming threat of water scarcity demand an immediate and collective response from society at large [16].

A previous study [17] shows that ESD and related concepts are not adequately integrated into higher education. The researchers argue for a more collaborative approach within academic institutions and suggest a comprehensive rethinking of how disciplines are structured to better integrate sustainability [17]. There is an urgent need for citizens to acquire the knowledge and behaviors necessary to push our societal boundaries further and drive a new wave of intellectual, consumer, and technological progress [18]. In this effort, teachers are recognized as key forces for change [19], with many experts highlighting their role as catalysts for transformation. Education must serve as a critical tool for exploring sustainability-related content, engaging not only intellectually but also emotionally and attitudinally to cultivate a deeper, more resonant understanding [20]. This approach ensures a resonant understanding that goes beyond cognitive engagement to include affective and embodied learning experiences. Such experiences are essential for students to internalize sustainability challenges through personal and collective emotional involvement, allowing lessons to extend beyond the classroom and become naturally embedded in everyday life and action.

The movement to weave sustainable development projects and hands-on activities into educational frameworks has seen a remarkable upsurge in interest and acceptance, a trend supported by a growing body of research [21,22]. The shift in education toward sustainability requires the use of interdisciplinary methods [23,24], the blending of theoretical knowledge with practical application [25], the encouragement of individual initiative alongside collaborative efforts [26,27], the stimulation of debate and ethical introspection [28,29], and the development of critical thinking [29]. Bringing these elements into the classroom, however, requires innovative teaching methods [30]. Notable in this regard is a previous study [31] that highlights the benefits of integrating information and communication technology (ICT) in secondary education to improve the understanding of sustainability concepts and positively influence students' emotional engagement with the material. Similarly, another study [32] focuses on an educational intervention targeting plastic pollution. This initiative encouraged students to investigate the issue and reflect on their consumption patterns, leading to an increased awareness of the link between human activities and environmental problems and a willingness to reduce their consumption habits. Another study [33] highlights the effectiveness of eco-didactic gardens in cultivating sustainable attitudes and skills, particularly through the practice of composting as a means of managing bio-waste. In addition, the educational value of digital newspaper articles has been highlighted for encouraging thoughtful consideration of current and future energy challenges [34], with the goal of promoting a vision of a sustainable energy future and clarifying the responsibilities of citizens in achieving this goal.

As mentioned above, sustainable development has been included as a fundamental pedagogical principle in the new Spanish Education Law [12], as well as in a variety of pedagogical and methodological frameworks proposed by a wide range of educators and researchers. Nevertheless, this area faces conceptual hurdles, particularly in terms of how students are expected to understand and articulate the benefits and potential drawbacks of practices such as the use of energy for sustainable development [35]. In essence, this perspective shifts the educational focus from simply teaching the scientific concept of energy to addressing energy issues through the lens of relevant socio-environmental challenges. This approach promotes a more holistic understanding of energy, emphasizing its implications and connections to broader environmental and societal concerns [36].

Today, the dynamics of energy production and consumption represent a critical issue within the social sciences [37]. The media regularly reports on the escalating cost of electricity, the environmental impact of fossil fuel use, and legislative efforts to promote renewable energy sources. The economic, societal, and environmental impacts of different energy sources, as well as the sectors that consume that energy and their associated costs, are at the center of the debate. In this sense, one of the SDGs set by UNESCO [38], specifically SDG 7, aims to provide affordable and clean energy. This goal focuses on the energy sector with the goal of providing universal access to affordable, sustainable, and modern energy solutions. This goal expands the traditional view of energy beyond electricity to include the use of natural gas for heating and gasoline for transportation, thereby broadening our understanding of the role of energy and its broad impacts.

In this regard, the debate about energy has been particularly prevalent in school curricula, making it one of the most discussed topics in formal education. Despite its pervasiveness, conventional methods of teaching about energy have largely failed to change public perceptions or behavior toward the dominant energy models in society. This traditional pedagogical approach has resulted in energy being perceived as a highly abstract concept that is difficult for the public to grasp [36]. This challenge underscores the need for innovative educational strategies that convey not only the technical aspects of energy, but also its societal implications and the urgent need for a shift towards more sustainable practices [35,39].

Understanding the impact of energy on society and the planet is essential and should be a primary focus of basic science education [40]. The topic of energy has been explored at various levels of education [35,41,42], revealing a consensus that current teaching methodologies—often focused on challenging established notions—require a significant conceptual shift [36,39]. Although these discussions reach students, the majority appear to be engaged in a passive learning experience rather than developing a deep, actionable understanding of energy issues [42]. Research shows that while teachers generally hold positive views of renewable energy, there is a noticeable disconnect between their positive attitudes and their ability to effectively teach renewable energy concepts [42]. One specific study [43] highlighted that 260 high school teachers in Jordan, 42% of whom were science teachers, showed a strong interest in renewable energy development but had a limited understanding of the subject matter, regardless of their teaching specialty. In addition, another study [44] indicated a widespread lack of knowledge about energy conversion processes among high school and senior high school teachers, despite a strong interest in the debate about renewable and non-renewable energy sources. This gap underscores the urgent need for enriched content knowledge and pedagogical strategies that better equip teachers to navigate and communicate the complexities of energy sustainability to their students.

Given this context, it is clear that teachers play a critical role in guiding students through the exploration of energy issues and helping them build practical, everyday knowledge. To play this role effectively, teachers must have a deep understanding of the subject matter and be familiar with the range of pedagogical approaches available. In addition, it is important for educators to recognize that energy is a multidisciplinary topic with significant societal implications [36]. This awareness will enable teachers to present energy in a way that connects with students on multiple levels, fostering more holistic and meaningful engagement with the subject.

While new curricula advocate for the hands-on development and understanding of topics such as energy and its impact on society, it is not clear that these topics are adequately represented in current educational guidelines. This ambiguity stems from the observation that educators often do not approach the concept of energy from a comprehensive scientific and practical perspective. Therefore, this article aims to enrich pedagogical understanding by examining how the concept of energy is integrated into the educational curricula governed by the LOMLOE [45,46], referring to previous analyses on the treatment of waste [47], energy [20] and water [48] within the Spanish educational framework governed

by the LOMCE [49]. This study methodically selects the concept of energy for investigation, with the intention of dissecting its scientific essence, its relevance to sustainability and its practical application in teaching strategies. In doing so, it seeks to fill the gap identified in previous studies [20] and to adapt to evolving pedagogical standards.

Consequently, this study addresses the following research question: How effectively do current secondary and baccalaureate curricula in Spain integrate and emphasize energy concepts in the context of sustainable and responsible development, and what improvements are needed to increase student engagement and understanding of these sustainability concepts?

2. Materials and Methods

This study adopted a qualitative research approach to address the questions posed in its four specific objectives. The methodology included a detailed lexicographical and content analysis of Royal Decrees 217/2022 [45] and 243/2022 [46], which relate to compulsory secondary education and the baccalaureate in Spain, respectively. In addition, the research examined Decrees 110/2022 [50] and 109/2022 [51] of the Autonomous Community of Extremadura, which focus on compulsory secondary education (CSE) and the baccalaureate. The objective was to conduct a comparative analysis between the national frameworks and regional implementations, with the aim of gaining insights into how energy concepts are integrated and emphasized across different educational levels and jurisdictions.

2.1. Objectives

The main objective of this study is to conduct a comprehensive analysis of how the concept of energy, viewed through the lens of sustainable and responsible development, is referenced within the regulatory framework for compulsory secondary education and the baccalaureate. This analysis includes both the national scope, through Decrees 217/2022 and 243/2022 [45,46], and the regional context, through Decrees 110/2022 and 109/2022 of the Autonomous Community of Extremadura [50,51]. By examining these decrees, the study seeks to shed light on the extent to which energy education is integrated and prioritized in Spanish education policy, highlighting the intersection of energy studies with the goals of sustainability and responsibility at different levels of governance.

The overall objective of this investigation is broken down into several detailed objectives:

1. Specific Objective 1 (SO1): To study the term "energy" from a lexicographic point of view, in terms of sustainability and responsibility, in the above-mentioned legislation;
2. Specific Objective 2 (SO2): To identify the subjects in which the concept of energy is taught from the point of view of responsibility and sustainability, as outlined in the Compulsory Secondary Education (CSE) and baccalaureate curricula;
3. Specific Objective 3 (SO3): To develop a set of categories to analyze the approach to the concept of energy from a perspective of sustainability and responsibility in the state legislation that regulates the CSE and baccalaureate curricula;
4. Specific Objective 4 (SO4): To study what curricular elements should be added to the current regulations to complete the education on the concept of energy from the perspective of responsibility and development;
5. Specific Objective 5 (SO5): To establish a system of indicators to study the cognitive demand of the concept of sustainable and responsible energy in the regulations governing compulsory secondary education and baccalaureate curricula;
6. Specific objective 6 (SO6): To carry out a comparative study on the impact or influence of the concept of energy, from the point of view of development and sustainability, in the compulsory secondary education and baccalaureate, comparing the previous regulations with the current ones.

These specific objectives collectively guide the study towards a nuanced understanding of the role and representation of energy in the Spanish educational system, with a focus on promoting a more sustainable and responsible approach to energy education.

2.2. Instruments and Procedures

To understand the treatment of energy from the perspective of responsibility and development, as they are embodied in the regulations governing secondary education in Spain, a comprehensive review of all mentions of energy in both national and regional decrees was undertaken. The focus was specifically on references that linked energy to concepts of development, efficiency, sustainability, responsibility, and related areas.

For each document that contained references to energy, sentences that logically presented a characterization of energy were meticulously examined. As a result of this in-depth study, a total of five distinct categories have been established to facilitate the organization of the references to the responsible energy field in the regulations studied. The derivation of these findings involved the analysis of sentences containing energy-related terminology, which were identified throughout the texts using a targeted word search tool.

The categories identified were as follows:

- Category I (Cat I)—Energy Sources: This category includes references to the diverse range of energy sources found on our planet, including the processes of their production and the subsequent stages involved;
- Category II (Cat II)—Energy Consumption/Use: This includes references to the importance of energy use at both the personal and industrial levels, covering aspects of consumption and its potential impacts;
- Category III (Cat III)—Technology/Renewable and Non-Renewable Energy: This category includes entries that contribute to the advancement of energy technology, including both renewable and non-renewable sources and all related facets;
- Category IV (Cat IV)—Awareness and Ethics: This includes references to the social and environmental impact of energy use, emphasizing the importance of responsible energy consumption;
- Category V (Cat V)—Sustainability and Energy Efficiency: This category includes references to all aspects of sustainability and energy efficiency related to energy.

These categories were established by previous research [20] and were formulated following an in-depth examination of the concept of energy through the lenses of responsibility, efficiency, and sustainability within the education sector. Beyond the term "energy" itself, several factors were considered across the categories: social factors in the Cat IV category, economic and development factors in the Cat II and Cat III categories, and environmental factors in the Cat I and Cat III categories. This holistic approach ensures a comprehensive understanding of energy, emphasizing its multiple impacts and the importance of integrating these considerations into educational curricula.

3. Results

This section outlines the findings from the analysis of various educational regulations that oversee compulsory secondary education and the baccalaureate in Spain. It is organized into subsections, each aligned with the specific objectives outlined earlier. Notably, the pursuit of Specific Objective 6 (SO6) is integrated across all subsections, addressed wherever its considerations are applicable. This approach ensures a thorough examination of the regulations, highlighting how the concept of energy, from perspectives of development and sustainability, is woven into Spain's educational frameworks.

3.1. Findings of the Analysis of the Concept of Energy from the Point of View of Development and Responsibility in the National and Regional Regulations of Extremadura

In this section, the findings related to Specific Objective 1 (SO1), as presented in this study, are detailed. To carry out the lexicographic analysis of the regulations governing the CSE and the baccalaureate curriculum in Spain, five different categories were defined to cover the concept of energy comprehensively. Table 1 shows the total number of references according to the different indicators identified in the regulations analyzed. This structured approach allows for a nuanced understanding of how energy is represented and prioritized in the educational standards established in Spain.

Table 1. Number of times (n) and percentage (%) of how often references to energy appear in the different categories in the specified regulations.

		Cat I	Cat II	Cat III	Cat IV	Cat V	Total
CSE	National curriculum	11 (40.7%)	1 (3.7%)	4 (14.8%)	5 (18.5%)	6 (22.3%)	27 (100%)
	Regional curriculum	15 (40.5%)	3 (8.1%)	4 (10.8%)	6 (16.2%)	9 (24.3%)	37 (100%)
Baccalaureate	National curriculum	27 (72.9%)	5 (13.5%)	1 (2.7%)	2 (5.4%)	2 (5.4%)	37 (100%)
	Regional curriculum	33 (63.4%)	8 (15.3%)	2 (3.8%)	6 (11.5%)	3 (5.7%)	52 (100%)
	Total number	86 (52.2%)	17 (11.1%)	11 (7.1%)	19 (12.4%)	20 (13.0%)	153 (100%)

As shown in Table 1, within the framework of secondary education in Spain, Royal Decree 217/2022 [45] and Decree 110/2022 [50] mention the concept of energy a total of 27 and 37 times, respectively. Cat I (Energy Sources) emerges as the most emphasized in both documents, while Cat II (Energy Consumption/Use) is the least represented, accounting for only 3.7% of the references in Royal Decree 217/2022. At the baccalaureate level, energy is mentioned 37 times in Royal Decree 243/2022 [46] and 52 times in Decree 109/2022 [51], with the latter showing a higher frequency of energy-related content.

A comparison with previous education regulations, specifically Decree 98/2016 [52], shows a more extensive coverage of the energy concept in the newer regulations of Extremadura. The total number of mentions increases to 89 in Decrees 110/2022 (for the CSE) and 109/2022 (for the baccalaureate), which represents a significant increase from the 65 instances recorded in Decree 98/2016, covering both the CSE and the baccalaureate [20]. This trend indicates an increased focus on energy within the current educational guidelines.

3.2. Findings of the Analysis of the Subjects in Which the Concept of Energy in Relation to Sustainable Development Is Integrated in the Curricula of CSE and the Baccalaureate

This subsection outlines the findings related to Specific Objective 2 (SO2), as presented in this study. In Spain, Compulsory Secondary Education (CSE) lasts four academic years and is intended for students between the ages of 12 and 16. Conversely, the non-compulsory segment of secondary education, the baccalaureate, is structured over two academic years for students aged 16 to 18. Table 2 provides a detailed summary of how the concept of energy, seen through the lens of sustainability, is integrated into the CSE curriculum. The table highlights the specific subjects in which the concept is introduced, the academic year in which it is taught, and the specific element of the curriculum in which it is included. The instances appear in learning situations (LSs), specific competences (SCs), evaluation criteria (EC), basic knowledge (BK) or in the introductory paragraph of the subject (In). The table excludes basic VET subjects as it focuses exclusively on CSE subjects.

It is noteworthy that the regional decree includes the concept of energy in three additional subjects compared to the national decree, specifically in Biology and Geology, Civic and Ethical Values Education, and Social Entrepreneurship and Sustainability. In addition, the subject of Physics and Chemistry emerges as the main source of energy-related references within CSE, accounting for 71.8% of the total mentions across all courses. The fourth year of CSE is highlighted as the course in which the topic of energy is most extensively covered, confirming previous studies [20], which noted the significant presence of this concept in the same school year under previous educational regulations (although it depends on the academic track chosen by students). Here, Basic Knowledge is identified as the curricular element with the most references to the concept. For the baccalaureate level, the findings are detailed in Table 3.

Table 2. Number and percentage of instances where the concept/reference of energy is mentioned in the context of development, responsibility, efficiency, and sustainability in the different subjects of the CSE curriculum.

Subject	Year	National Curriculum						Regional Curriculum						Total	
		LS	SC	EC	BK	In	%	LS	SC	EC	BK	In	%	N	%
Physics and Chemistry	1st				6	4	18.1	1				1	2.5	12	8.6
	2nd				6	4	18.1	1			15	1	21.2	27	19.4
	3rd				5	4	16.3	1			15	1	21.2	27	19.4
	4th				10	4	25.4	1			18	1	25	34	24.4
Technology	1st		1			2	5.4			1	4	1	7.5	9	6.4
	2nd		1			2	5.4			1	4	1	7.5	9	6.4
	3rd		1			2	5.4			1	4	1	7.5	9	6.4
	4th		1			2	5.4			1	4	1	7.5	9	6.4
Biology and Geology	4th										1		1.2	1	0.7
Education in Civic and Ethical Values	2nd										2		2.5	2	1.4
Social Entrepreneurship and Sustainability	2nd									1			1.2	1	0.7
TOTAL		0	4	0	27	24	100	4	0	5	67	8	100	139	100

Table 3. Number and percentage of instances where the concept/reference of energy is mentioned in the context of development, responsibility, efficiency, and sustainability in different subjects of the baccalaureate curriculum.

Subject	Year	National Curriculum						Regional Curriculum						Total	
		LS	SC	EC	BK	In	%	LS	SC	EC	BK	In	%	N	%
Biology, Geology and Environmental Sciences	1st				1		2.4							1	1
	2nd				1		2.4							1	1
General Sciences	2nd				5	2	17.0	2			10	1	26.0	20	21.9
Physics	2nd				5	3	19.5				4		8.0	12	13.1
Physics and Chemistry	1st				5	3	19.5				12	1	26.0	21	23.0
Geography	2nd				1		2.4				1		2.0	2	2.1
Chemistry	2nd				7		17.0				8		16.0	15	16.4
Technology and Engineering I	1st		1	2	1	1	12.1		1	2	2		10.0	10	10.9
Technology and Engineering II	2nd			2		1	7.3		1				2.0	4	4.3
Ecology and Environmental Sustainability	2nd									1	3		8.0	4	4.3
Economy	1st										1		2.0	1	1.0
Philosophy	1st												2.0	1	1.0
TOTAL		0	1	4	26	10	100	3	2	3	41	1	100	91	100

At the baccalaureate level, the regional decree introduces the concept of energy in three subjects not covered by the national decree, namely Ecology and Environmental Sustainability, Economics and Philosophy. Specifically, most references are found in the subjects of Physics and Chemistry and General Sciences during the second year of the baccalaureate, with 21 and 20 references, respectively, accounting for 23.0% and 21.9% of the total mentions. Chemistry follows with 15 references. Technology and Engineering I and Physics also feature prominently, with 10 and 12 references, respectively, representing 10.9% and 13.1% of the total. The subjects least affected by this concept include Economics, Philosophy, Ecology and Environmental Sustainability (an optional subject), Technology

and Engineering II, Geography, Biology, Geology and Environmental Sciences. It is also significant to note that in both sets of regulations, most references are categorized under Basic Knowledge.

3.3. Analysis of How the Concept of Energy in Relation to Sustainable Development Is Dealt with in the Regulations Governing CSE and the Baccalaureate Curricula

This subsection details the findings related to Specific Objective 3 (SO3), as outlined in this study. To assess whether the concept of energy is approached from a point of view of sustainable development and responsibility, we carefully selected and analyzed every sentence that referred to energy, and then organized them into five predefined categories, as described in Section 2.2. This analysis was carried out specifically using the national regulations for both educational levels—Royal Decree 217/2022 for the CSE and Royal Decree 243/2022 for the baccalaureate. The findings of the study of these decrees are as follows:

CATEGORY I—Energy Sources (Cat I):

In CSE, 11 sentences mentioning energy sources are found in all subjects that include the concept under study, with Physics and Chemistry standing out as the most significant contributor in this category. The references are also present in subjects such as Technology and Applied Sciences (basic VET education level). Seven of these sentences deal with different energy sources available on our planet, describing their manifestations, basic characteristics, and transfer processes. One sentence uniquely addresses energy in a literary context, while another discusses the notion of knowledge, emphasizing the importance of understanding energy sources for a better understanding.

At the baccalaureate level, there are 24 sentences on energy sources in the second year Physics, Chemistry and General Science curricula, which also extend to the first year Physics and Chemistry subject. These sentences focus primarily on types of energy, theorems, conservation principles, and energy exchange. Highlights include discussions of "Matter and Energy" and "Raw Materials and Energy Sources", illustrating a comprehensive exploration of energy sources within the science studies of the baccalaureate.

CATEGORY II—Energy Consumption/Use (Cat II):

At the CSE level, energy consumption and its appropriate use are emphasized in four sentences in the subjects of Physics and Chemistry and Applied Sciences (basic VET education level), with a significant 75% emphasis in Physics and Chemistry. One sentence addresses both domestic and industrial energy use, while the other three discuss application methods, practical uses, and the environmental consequences of energy consumption. Phrases such as "domestic and industrial use of energy" are examples found.

At the baccalaureate stage, reflections on energy consumption, along with considerations of its proper or improper use, are articulated in four sentences in subjects taught in both the first and second years of the baccalaureate. Technology and Engineering subjects contain half of these references, while Physics and Chemistry and Physics together account for the other 25%. These references are designed to evaluate energy use and its application in real-world scenarios, covering both industrial and domestic spheres. In addition, one reference deals with the processes of energy generation, transportation, distribution, and supply, as well as the functioning of energy markets, with phrases such as "systems of generation, transportation, and distribution of energy and supply, as well as the functioning of energy markets".

CATEGORY III—Technology, Renewable and Non-Renewable Energy (Cat III):

In the context of CSE, there is a notable sentence within the Physics and Chemistry curriculum that addresses renewable and non-renewable energy sources. This sentence is designed to encourage critical thinking among students regarding the variety of energy sources available and asks them to categorize these sources into renewable and non-renewable types based on sustainability considerations. This statement is categorized

separately from Cat I because it does not focus directly on the concept of an energy source, but rather on the discussion of renewable energy as a way to improve sustainability.

At the baccalaureate level, the second-year General Science subject includes a sentence that focuses on renewable and non-renewable energy. The identifiable phrase within this discussion is "Renewable Energy", which represents an educational effort to highlight the importance of renewable energy sources as opposed to non-renewable ones, in line with the broader sustainability goals of the curriculum.

CATEGORY IV—Awareness and Ethics (Cat IV):

At the CSE level, there are five references that deal with the social and environmental impacts of energy use. These references are distributed across the subjects of Physics and Chemistry and Applied Sciences (basic VET education level). Each of these sentences is designed to develop students' critical thinking skills, enabling them to assess the impact of energy consumption on both the environment and society.

In the baccalaureate curriculum, two sentences focus on the social and environmental impacts observed in our daily lives and in society at large. These references are identified within the first- and second-year baccalaureate courses in Physics and Chemistry, as well as Technology and Engineering. They focus on the recognition and critical evaluation of the role and impact of energy. An example of a phrase found in this category is "The use and impact of energy in society and the environment", highlighting the curriculum's intention to promote a deeper understanding and ethical consideration of energy use.

CATEGORY V—Sustainability and Energy Efficiency (Cat V):

Within the framework of CSE, there is a sentence that emphasizes energy efficiency as a means to achieve universal access to energy through the lens of sustainable development. This singular mention reflects an educational priority to instill an understanding of how efficient energy use can contribute to sustainability goals.

At the baccalaureate level, the discourse expands to include two sentences that address sustainability, efficiency, and the broader aspects of development within the energy sector. In both contexts, the evaluation of energy depends on its efficiency and the sustainability of energy production methods. An example of the comprehensive approach taken in these discussions is "Evaluate the different systems of electrical energy production and energy markets, studying their characteristics, calculating their magnitudes, and assessing their efficiency". This phrase demonstrates the curriculum's commitment to not only educate students about energy efficiency, but also equip them with the skills to critically evaluate and understand the broader implications of energy production and consumption.

3.4. Findings of the Cognitive Demands Associated with the Concept of Energy within the Regulations Governing the Curriculum for Compulsory Secondary Education and the Baccalaureate

In this sub section, we detail the findings corresponding to Specific Objective 5 (SO5), as defined in this study. To examine the cognitive demands associated with the concept of energy, particularly in terms of sustainability and responsibility, we revisited the sentences previously analyzed. The aim of this reexamination was to measure the effort required by students to assimilate and understand the concept of energy in the context of sustainable development, as integrated in the curricula of CSE and the baccalaureate. Subsequently, we established a set of indicators like those used in previous analyses [20,48,53]. These indicators were then adapted and refined to meet the specific needs of our investigation, resulting in the creation of a framework for coding the identified indicators following the curriculum analysis. As shown in Table 4, these indicators enumerate six distinct aspects that reflect the different cognitive demands placed on students. In addition, they outline different activities, inquiries, or challenges that can be introduced, along with their potential applications or different contexts for classroom implementation.

Table 4. Indicators for assessing cognitive demand.

Code	Category	Type of Activity to Be Developed	Applications in the Classroom
KNO	**Knowledge** Simple level. Does not require practice.	Questions or problems that require the student to respond based on information provided, look up information in a book, or connect two concepts using a linking system.	Situations that require memorization, defining concepts, searching for a concept in a textbook, or engaging in relational activities.
COM	**Comprehension** Abstract level. Requires understanding.	Questions or problems that require the student to describe the characteristics of an object, interpret data, or use scientific facts to support or refute a claim.	Situations that require detailed explanations of features, categorizing information, or interpreting or justifying information.
APP	**Application** Complex level. Requires calculations.	Questions or problems that require the student to use a specific element in problem solving.	Situations that require the use of formulas or other elements for solution.
ANA	**Analysis** Complex level. Requires processing of information.	Questions or problems that require the student to analyze the characteristics of two or more elements or the dynamics of a system from the information provided.	Situations that require making comparisons or predictions.
SYN	**Synthesis** Abstract level. Requires abstract work.	Questions or problems that require students to devise a method for solving a problem or to support a claim or concept.	Situations that require designing or demonstrating a solution.
EVA	**Evaluation** Combines abstract and complex levels.	Questions or problems that require students to evaluate or assess the validity of an idea, claim, etc.	Situations that require reasoning to support an idea, assumption, etc.

From the detailed analysis of the sentences, the following findings were derived. In relation to the Knowledge indicator (KNO), six sentences were identified within the CSE curriculum, specifically within the subject of Physics and Chemistry. In addition, there was a notable mention in the subject of Applied Sciences (basic VET education level). At the baccalaureate level, a total of thirteen sentences were pinpointed in various subjects, including Biology, General Sciences, Physics, Physics and Chemistry, Geography, and Chemistry. These represent 39.3% of all sentences analyzed in this context. Among the extracted sentences, examples such as "raw materials and energy sources" were observed.

Regarding the Comprehension (COM) indicator, three cases were identified at the CSE level, all in the subject of Physics and Chemistry. Proceeding to the baccalaureate level, a total of 11 sentences were noted in subjects such as General Sciences, Physics, Physics and Chemistry, Chemistry and General Sciences, representing 33.3% of the total sentences analyzed. An example of the sentences found was "Relationship between power and mechanical energy and its conservation".

For the Application (APP) indicator, at the CSE level, its presence was noted in two sentences within the subjects of Physics and Chemistry and Technology. At the baccalaureate level, application was underlined in a single sentence within the subject of Physics and Chemistry. The sentence was as follows: "Potential energy and kinetic energy of a simple system: application of the conservation of mechanical energy in conservative and non-conservative systems and in the study of the causes that produce the motion of objects in the real world".

Regarding the Analysis indicator (ANA), there were four sentences in the CSE that included analysis as a cognitive requirement. These were found in the subjects of Physics and Chemistry and Applied Sciences (basic VET education level). At the baccalaureate level, analysis was required in a sentence related to the subject of chemistry, which was "Energy transfer. Work and heat as forms of energy transfer between systems related to forces".

As for the Synthesis (SYN) indicator, at the CSE level, it was represented in a sentence found in the subject of Physics and Chemistry. However, at the baccalaureate level, there were no sentences that required students to be able to synthesize. The relevant sentence at CSE was as follows: "Solve problems related to mechanical energy in everyday situations".

Finally, in terms of the Evaluation indicator (EVA), it manifested in six sentences within the CSE framework, specifically in the subjects of Physics and Chemistry, Technology and Applied Sciences (basic VET education level). At the baccalaureate level, this indicator appeared in seven sentences in the subjects of Physics, Technology and Engineering, and Physics and Chemistry. An example of content related to this indicator was "Evaluate the different systems of electrical energy production and energy markets, study their characteristics, calculate their magnitudes, and assess their efficiency".

4. Discussion

Upon concluding the analysis, it is clear that the regional legislation for both levels of education emphasizes the concept of energy from a responsibility perspective more than the national regulations, although both show a clear commitment to the concept, continuing the trend observed in previous regulations [20]. In the stage of CSE, the current regulations show a significant number of references to the concept, although these are mainly concentrated in the subject of Physics and Chemistry, which account for 71.4% of the total. It is also important to distinguish between the national and regional decrees, since they differ in the number of subjects that refer to the concept in question.

Royal Decree 217/2022, which relates to national CSE, identifies three subjects—Physics and Chemistry, Technology and Applied Sciences—that include discussions on energy in the areas studied. This concept can also be explored through monographic works, interdisciplinary projects, or collaborations with community services. Conversely, regional Decree 110/2022 expands this to five subjects, in addition to monographic works, interdisciplinary projects or collaborations with community services, incorporating energy as a key topic of exploration.

The approach through which students engage with and acquire knowledge about energy differs significantly between the two sets of regulations. Under both national and regional decrees, the subjects of Physics and Chemistry, along with Biology and Geology, are compulsory during the first three years of education, with students having the option to choose them in the fourth year (they are not compulsory at this final stage, but optional). However, according to the provisions of the national decree, if students choose Biology and Geology, they will encounter the concept of energy mainly in the ESO stage, within the optional subject of Technology, which must be chosen at least once during the first three years. Conversely, with the regional decree, energy is also addressed within the subject of Biology and Geology, which is compulsory during the first three years. The continuation of this concept in the fourth year then depends on the subjects chosen by the student, highlighting a structured yet flexible approach to the integration of energy concepts within the curriculum.

Notably, the regional decree expands the range of subjects that include the study of energy. Specifically, subjects such as Biology and Geology, Education in Civic and Ethical Values, and Social Entrepreneurship and Sustainability are included in the curriculum, a distinction not found in the national decree for CSE. As highlighted above, Physics and Chemistry are the most important subjects in this context, with Technology a distant second. The inclusion of Biology and Geology, Education in Civic and Ethical Values, and Social Entrepreneurship and Sustainability exclusively within the regional decree provides students in Extremadura with a wider opportunity to engage with this central concept. Furthermore, in the field of basic vocational training cycles, the concept of energy is only addressed in one subject, Applied Sciences, where its impact on the curriculum is particularly limited.

In terms of cognitive demands in CSE, the curriculum formulation during this stage mainly requires students to have knowledge about energy. This includes analyzing solu-

tions derived from problems or evaluating different scenarios, as well as critiquing cases presented in society. This approach aims to foster a critical capacity in students, enabling them to fully understand energy use at both the domestic and industrial levels. Such an educational focus is crucial to cultivating the necessary awareness and understanding today.

At the baccalaureate level, a notable difference is that only the regional legislation includes the concept analyzed in the subject of Philosophy, although the coverage is relatively superficial. In essence, an in-depth exploration of this concept occurs mainly when students opt for the Science and Technology pathway in both the first and second years of the baccalaureate, which is applicable under both the national and regional legislative frameworks. Another important observation from the study is the localization of the concept mainly within the subjects of Physics and Chemistry, Physics, Chemistry, General Sciences and Technology and Engineering. Since these subjects are elective rather than mandatory, their study depends on student choice.

Moreover, it is important to emphasize that the baccalaureate level offers a more detailed curriculum on energy education than the CSE level. Specifically, the concept of energy is present in 11 subjects at the baccalaureate level, as opposed to five subjects at the CSE level. Within the CSE, Physics and Chemistry play a central role in shaping students' understanding of this concept throughout the first four years and are the subjects with the greatest influence on energy education. Physics and Chemistry is a mandatory subject unless the student opts for Biology and Geology.

In the baccalaureate phase, regarding the cognitive demands related to the concept of energy, it is observed that the primary cognitive demands placed on students revolve around the acquisition of knowledge about energy and its understanding. There are no requirements within the category of synthesis, and the requirements for application and analysis are very minimal, each appearing in only a single sentence.

5. Conclusions

The purpose of this study was to investigate how effectively current secondary and baccalaureate curricula in Spain integrate and emphasize energy concepts in the context of sustainable and responsible development. Our objectives focused on identifying gaps in existing educational strategies and recommending pedagogical improvements to increase student engagement and understanding.

Our findings indicate that while significant efforts have been made to integrate sustainability into the curriculum, there are significant gaps in the way these concepts are taught, particularly in engaging students at a deeper, more affective level. The insights derived from our analysis offer practical solutions that directly address these shortcomings. By promoting an interdisciplinary approach and emphasizing the importance of collaborative efforts in teacher training, our study addresses the urgent need for pedagogical strategies that not only inform, but also empower students to actively engage in sustainable practices.

The persistence of various socio-environmental challenges, manifested at different scales and with the potential for escalating consequences, underscores the need to examine the real obstacles to achieving a civic education that critically examines our development paradigms. This observation, highlighted in previous research [32], points to the need to go beyond educational methodologies that focus solely on disseminating information about environmental issues. Instead, there is a call for approaches that promote critical engagement with reality, fostering active participation and informed decision-making within actual environmental conflict scenarios [54]. An example of the complexity of these scenarios is the sustainability assessment of renewable energy sources. Contrary to popular belief, renewable energy sources are not inherently sustainable. For example, research has shown that solar farms can sometimes be inconsistent with the broader goals of the Sustainable Development Goals, highlighting the challenge of creating sustainability assessment frameworks for energy sources [55]. This complexity underscores the need for a curriculum that not only provides knowledge, but also cultivates a deep, multidimensional understanding of sustainability issues.

The overarching goal is to cultivate not only individuals who are critically aware of the developmental trajectory of our society, but also communities of collective change, thus prompting a reassessment of classroom practices [56]. Such curricular transformations will affect the fundamental principles of action, the curation and incorporation of specific content, and evaluation mechanisms. These adjustments are envisioned within a competency-based framework that advocates for the preparation of students to navigate and influence the economic, social, and natural realms we inhabit [57]. To ensure that our citizens can form independent and well-informed perspectives on energy-related issues, a comprehensive understanding that spans multiple disciplines is essential. Therefore, any effort to address energy issues should carefully integrate different fields of knowledge and promote interdisciplinary efforts to avoid conceptual redundancies [58]. This interdisciplinary approach is essential to achieve a holistic understanding and engagement with energy issues in educational settings.

We recommend incorporating experiential and project-based learning initiatives to connect the theoretical and practical aspects of sustainability education, which directly addresses our goal of improving pedagogical effectiveness. In addition, forging partnerships with local museums and environmental organizations provides tangible ways to enrich the educational experience and help deepen students' connection to the subjects they are studying.

To effectively update energy education, it is essential to focus on integrating subjects like electric vehicles and carbon footprints into the curriculum. Despite coverage of ecological footprints, the omission of carbon footprints—crucial for understanding the full spectrum of environmental impact, especially in terms of climate change—is significant. The call to action for reducing carbon emissions, highlighted during the 2009 United Nations Conference in Copenhagen, stresses the importance of addressing the carbon footprint from sectors like transportation, a major emissions contributor. Introducing electric vehicles in the curriculum not only connects students directly with sustainable energy innovations but also significantly aligns with reducing the transportation sector's carbon footprint. By educating students on the benefits and mechanics of electric vehicles alongside the broader concept of carbon footprints, the curriculum would not only provide a more comprehensive understanding of the role of energy in environmental sustainability, but also equip students with the knowledge to participate in and advocate for emissions reduction. Incorporating these elements into the curriculum requires a thoughtful approach to ensure that students understand the importance of sustainable energy practices and their potential to mitigate climate change. This proposed inclusion aims to foster a more informed and responsible future generation, capable of making decisions that positively contribute to environmental stewardship and sustainability.

Moreover, the effectiveness of these educational transformations depends critically on the quality of teacher training and the establishment of robust collaborations across education and knowledge dissemination sectors. Training programs must equip educators not only with the necessary content knowledge, but also with the pedagogical skills to effectively engage students in complex sustainability issues [59,60]. Collaboration between academia, the museographic world, and educational institutions is essential to create enriched learning environments that facilitate the practical application of theoretical knowledge. Such partnerships can enhance the delivery of knowledge through multiple learning modalities, integrating museum experiences that provide tangible connections to theoretical concepts discussed in the classroom. This integrated approach helps bridge the gap between learning and real-world application, ensuring that students are not only well informed, but also prepared to actively participate in addressing the multifaceted challenges of sustainability. Additionally, interdisciplinary approaches to sustainability education should transcend traditional boundaries between disciplines to include a holistic integration of human, bodily experiences and the broader human condition, as well as technological advances and societal structures. This approach will facilitate a more compre-

hensive understanding of sustainability that encompasses both individual experiences and collective societal impacts.

In conclusion, this research highlights the need to seamlessly weave energy education into the broader narrative of sustainability and responsibility, particularly within the Spanish educational landscape. An examination of curricular content and pedagogical strategies at different levels of education reveals fertile ground for progress. The suggestion of including contemporary issues in the curriculum goes beyond a mere recommendation and emerges as an essential step in raising a generation that is not only well informed, but also capable of making decisions that are conducive to sustainable development goals. This article makes clear that the realization of such an aspirational future depends on the commitment of educators, curriculum designers, and policy makers to adopt interdisciplinary methodologies, refine teaching practices, and, most importantly, foster critical and ethical reasoning among students. Moreover, while fostering critical thinkers is paramount, a sense of community and collective efficacy must be instilled in students. This will prepare not only individuals who are capable of critical analysis and decision-making, but also communities that can work together to create sustainable change. This focus on collective action is essential to addressing the complex challenges of sustainability that no one individual can address alone. Through such comprehensive measures, we aim to empower our students not only to develop a deep understanding of energy and its broader implications, but also to equip them with the ability to make significant contributions to a sustainable and just future for all.

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