

Original Article

Solar Power in the Philippine Science Curriculum: A Qualitative Analysis

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Received: 15 August 2026; Revised: 22 September 2026;
Accepted: 26 September 2026; Published: 30 September 2026

DOI: <https://doi.org/10.66074/W8R1J5P4L>

Abstract

As the country pursues sustainability, strengthening solar power education becomes increasingly important. Based on this research, solar power was found in the MATATAG Science Curriculum Guide for grades 7 and 10, as well as in the Senior High School Earth and Space Science 1 Curriculum Guide. Qualitative document analysis was used to systematically analyze and code official curriculum documents to assess the scope of solar power and the curriculum content and learning competencies. The analysis distinguished explicit solar-power references from indirect or contextual representations through broader concepts such as renewable energy, electricity generation, climate change, sustainability, and environmental impacts. Thematic analysis was conducted using Braun and Clarke's approach, which included familiarization, coding, theme development, theme review, theme definition, and theme reporting. Four curriculum entries were found and analyzed, one from Grade 7, two from Grade 10, and one from Senior High School. The analysis generated four themes: solar power is represented primarily through the broader renewable-energy category; environmental sustainability and climate action serve as dominant contexts; evidence of solar-specific technological development remains limited; and an explicit progression of solar learning has not yet been established. The results suggest that the curriculum grounds science literacy on solar energy within the broader context of renewable energy and sustainability. However, there is less direct evidence of a clear progression in knowledge, technology, and advanced applications related to solar power. The findings indicate potential areas for further

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curriculum development to strengthen existing competencies in renewable energy and to provide more explicit opportunities for learners to explain, investigate, evaluate, and design solar energy applications.

Keywords: curriculum analysis, earth and space science, MATATAG curriculum, renewable energy, science curriculum, science literacy and solar energy

1. Introduction

Renewable technologies have become increasingly prominent in the world's transition to more sustainable energy systems, as they can help reduce reliance on traditional energy sources and mitigate environmental and climate issues. Its increasing adoption requires not only technological innovation and appropriate energy policies but also a population capable of understanding the scientific principles, technological processes, and environmental implications associated with solar-energy systems. As a result, solar energy education has become relevant to developing the knowledge and competencies needed to grasp these emerging energy technologies and sustainability challenges (Hoque et al., 2022; Santillán & Cedano, 2023).

This is of great significance in the Philippines as part of the world's relevance to solar energy. The Philippines is on a journey toward a more energy-efficient and eco-friendly economy, with the Department of Energy (DOE) aiming for 35% renewable energy in the country's energy generation mix by 2030 and 50% by 2040 (Philippine News Agency [PNA], 2021). Thus, linking national energy priorities to basic education can help ensure that learners are introduced to scientific and technological knowledge relevant to the country's new energy economy. This is also aligned with the general function of education to produce energy-literate citizens who can comprehend energy production, use, efficiency, and environmental implications (Santillán & Cedano, 2023).

Education then plays a key role in providing learners with scientific knowledge that can be applied to help them understand technologies like solar power. The Philippine Department of Education's MATATAG Curriculum focuses on scientific inquiry and the application of scientific knowledge in real-life scenarios (Department of Education [DepEd], 2023). In this context, solar energy can be linked to concepts in energy, electricity, Earth and space science, environmental sustainability, technology, and engineering. The presence of related concepts does not per se imply a unified place for solar power in the curriculum. Solar energy can be specified in certain competencies, distributed across other scientific concepts and skills, or presented as a case of renewable energy.

The educational benefits of solar energy go beyond its classification as a renewable energy. Solar-energy contexts can be used to facilitate learning about solar

radiation, energy transfer and transformation, electricity, photovoltaic systems, energy efficiency, and environmental consequences. The literature shows that solar-energy contexts can enhance STEM learning (Shahbazloo & Mirzaie, 2023) and engineering-design contexts can link solar-energy science to real-world engineering design problems (Sung et al., 2024; Tang et al., 2026). Solar energy draws on knowledge and skills from several STEM/STEAM disciplines, particularly in understanding photovoltaic technologies and applying scientific and engineering principles to the design, installation, operation, and maintenance of solar energy systems (Amalu et al., 2023). These studies indicate that the curricular benefits of solar energy involve opportunities to explain, investigate, design, evaluate, and apply the power source rather than just advocating for it.

As such, it is important to take into account the frequency of mentions of renewable energy and/or solar energy in curricular analysis. A curriculum provides the order and level of detail for each concept; it provides context for the concepts; it provides connections to other content; and it provides progression of learning from one grade level to another. In the case of solar power, the relevant dimensions are explicitness, conceptual depth, context, grade-level and learning-area coverage, and continuity or progression. Results from previous energy education research indicate that concepts can be presented at multiple school levels. Yet, learners are not afforded enough opportunities to develop or apply them at more complex levels (Markóczy Revák et al., 2023).

Learning progressions are particularly important because the understanding of solar power requires learners to make connections over time. Information on the Sun, energy, light, and heat could also help inform understanding of energy transformation, electricity, PV technology, efficiency, and the environmental and technological impacts of solar-energy-based systems. The importance of developing coherent understanding across energy contexts is emphasized by Nordine et al. (2018), who argue that energy instruction should provide learners with conceptual tools that can be applied consistently across different phenomena and disciplinary contexts. From this perspective, when related energy concepts are introduced without deliberate connections across learning experiences, students may encounter them as separate ideas rather than as parts of a coherent understanding of energy. This is particularly relevant to solar-power learning, where concepts such as energy transfer, energy conversion, electricity, and renewable energy need to be meaningfully connected to support progressively deeper understanding of solar-energy systems.

Also, energy literacy is not only about the awareness of the benefits of renewable energy. It involves information on the generation, transportation, storage, distribution, consumption, efficiency, and environmental and social impacts of energy decisions (Santillán & Cedano, 2023). Similarly, opportunities for learners to develop informed understanding, not awareness only, of renewable energy are needed (Hoque et al., 2022). Therefore, it is necessary to study the representation of solar power by examining what is explicitly written in the curriculum about it, as well as the broader renewable energy contexts in which solar power could be situated.

The field of solar technology is highly interdisciplinary. The solar energy field relies on scientific knowledge and technological, engineering, mathematical, and problem-solving skills (Amalu et al., 2023). Education research has demonstrated that solar-energy-based contexts can facilitate authentic engineering design and interdisciplinary learning (Sung et al., 2024; Tang et al., 2026). The question in the curriculum is then not just whether solar energy is present, but whether the documented representation provides a way to introduce students to basic concepts, then to the scientific explanation and/or critical evaluation, and finally to the application of solar power.

While research in the area of solar-energy education has been conducted and analyzed, solar-energy STEM interventions, energy literacy, engineering design, and solar-energy skills have received more attention; less research has been conducted and analyzed on the representation of solar energy in Philippine basic education curriculum documents (Amalu et al., 2023; Shahbazloo & Mirzaie, 2023; Sung et al., 2024; Tang et al., 2026). Comparable studies on energy concepts in textbooks and renewable-energy education offer useful perspectives for comparison (Hoque et al., 2022; Markóczi Revák et al., 2023), but they have not determined the distribution of solar-specific and renewable-energy references in the Philippine MATATAG curriculum. The present study aims to fill this gap in the curriculum.

The analysis thus explores the locations of references to solar in the content, to renewable energy as a broad frame of reference, and the development of the documented content across the selected grade levels and learning areas. Particular attention is given to the explicitness of references to the scientific/technological depth of the representation, the framing in the environmental context, and the degree of vertical articulation of the documents examined. This practice helps prevent the wrongful interpretation of all mentions of renewable energy as referring to solar energy.

This study aimed to analyze the integration and representation of solar power concepts in the MATATAG and K-12 curricula using a document analysis approach. Specifically, it sought to examine how solar power was represented in terms of learning competencies and content standards, determine how renewable energy and solar power were integrated across science concepts and principles, sustainability, technological applications, and community relevance, and identify curricular gaps based on the findings that could inform the strengthened integration of solar power education in the curriculum.

2. Methodology

This study used a qualitative document analysis research design in studying the representation of solar power in the Philippine basic education science curriculum. Document analysis is the examination and interpretation of documentary data to reveal meaning, patterns, and relationships in the phenomenon under investigation (Bowen, 2009). The design was suitable because the study was not concerned with classroom

implementation, teacher practices, or learner outcomes, but rather with the content, organization, contextualization, and conceptual development of solar power in curriculum documents. The study was conducted in the context of the Philippine basic education curriculum, specifically, on the official curriculum documents issued or recognized by the Department of Education (DepEd). The document retrieval, organization, examination, coding, and interpretation took place from August to December 2025. This period is not related to the publication date of the curriculum documents, but rather to the research activities the researcher has conducted.

2.1 Documentary Corpus and Sampling

The unit of analysis was the official curriculum document, and, more specifically, the curriculum entries, including relevant content and learning competencies. The documentary corpus included the following science curriculum guides: MATATAG Science Curriculum Guides for Grades 7-10 and the Earth and Space Science 1 Curriculum Guide for Senior High School. The study did not, therefore, claim to include all Philippine basic education curriculum documents for the following reasons: First, the study was limited to the curriculum scope of the Junior High School and Senior High School defined by the Philippine Department of Education. Second, the study did not cover the curriculum scope of all Basic Education Curriculum documents. Purposive sampling was used to identify the official curriculum documents within this predefined scope. The sampling was based on their curricular relevance rather than on the prior presence of solar-power content. All relevant curriculum statements were analyzed in the selected documents for evidence of solar power and, more generally, for evidence on renewable energy and related concepts. The criteria for inclusion were: (1) the document was an official curriculum of the Department of Education (DepEd); (2) it corresponded to Grades 7-12 in the scope of the study; (3) it had science curriculum content on solar power, renewable energy, electricity, environmental sustainability, climate change, and other scientific and technological concepts; and (4) it was made publicly available and was sufficiently complete for systematic examination. If they were not curriculum documents, were used mainly for teaching and learning purposes, were not in the defined scope of the grade level and subject, did not contain adequate curricular information for analysis, or were incomplete or unavailable, they were excluded from the documents. The documents within the defined scope were identified and analyzed as a whole, and curriculum entries were extracted for detailed analysis. Entries which contained references to solar power, renewable energy, electricity, energy transformation, environmental sustainability, climate change, and scientific and technological concepts relating to the examination of the representation of solar power were extracted. This was a basic extraction used only after the selection of documents, not as a basis for selecting the curriculum documents themselves. The extracted entries were then sorted into the categories of explicit solar-specific evidence and contextual

renewable energy evidence, based on how well the curriculum represented solar power.

2.2 Research Instrument

The primary instrument for data collection and organization was a Document Analysis Matrix developed by a researcher. The matrix was developed based on the research questions and provided a consistent framework for collecting, structuring, and analyzing curriculum evidence. It included the document title, the document's source, the level and subject, the topic or content area of the curriculum, the learning competency or performance standard, the relevant curriculum statement, the type of evidence, the mode of representation of solar power, and an analytic interpretation. The following analytical dimensions were employed to examine the presence, explicitness, conceptual depth, progression, alignment, and contextualization of solar power. The matrix separated the solar-specific evidence from the contextual evidence. Explicit evidence about solar was direct and specific to solar power, solar energy, photovoltaic technology, and/or identifiable solar technologies. Broadly, renewable energy, electricity generation, energy transformations, sustainability, climate change, environmental impacts, energy conservation, and technological/engineering applications were found in the context. This contextual evidence was not considered to be a direct indication of solar-power teaching.

2.3 Data Collection Procedure

Data collection followed a systematic and chronological procedure. First, the researcher identified the official DepEd curriculum documents within the predefined scope and organized them by grade level, subject, quarter, and document type. Second, each document was read repeatedly to become familiar with its structure, content, learning competencies, and performance expectations. Third, potentially relevant statements were identified and extracted together with their surrounding curricular context. Fourth, the extracted statements were entered into the Document Analysis Matrix and classified according to their relationship to solar power. Fifth, the researcher reviewed the extracted evidence against the original curriculum documents to ensure that statements were accurately represented and that interpretations were not detached from their curricular context. Four curriculum entries were ultimately identified for detailed analysis: one from Grade 7, two from Grade 10, and one from the Senior High School Earth and Space Science 1 Curriculum Guide.

2.4 Data Analysis

The extracted documentary evidence was analyzed thematically using the six-phase approach of Braun and Clarke (2006). The analysis followed six recursive phases. First, the researcher familiarized themselves with the documents by repeatedly

reading relevant sections and their surrounding context. Second, initial codes were systematically generated from statements relevant to the research objectives, including explicit references to solar power, renewable energy, energy transformation, electricity generation, sustainability, climate change, environmental impacts, energy conservation, and technological applications. Third, related codes were collated into candidate themes. Fourth, candidate themes were reviewed against the extracted statements and the broader context of the curriculum documents to determine whether they constituted coherent, well-supported patterns. Fifth, each theme was defined and named according to its central organizing concept, scope, and distinction from other themes. Sixth, the final themes were synthesized into an analytical narrative supported by the relevant curriculum evidence.

A key analytical criterion was the distinction between direct and contextual evidence. Statements were classified as explicit solar-specific evidence only when solar power, solar energy, photovoltaic technology, or another clearly identifiable solar technology was directly represented. Statements concerning renewable energy or related environmental and energy concepts were classified as contextual evidence when solar power was not explicitly identified. This distinction prevented general statements about renewable energy from being automatically interpreted as evidence of solar-specific instruction.

An audit trail was maintained throughout the analysis, documenting the documents examined, the entries extracted, the coding decisions, the candidate themes, the revisions to interpretations, and the final thematic definitions. The researcher also retained the original wording and relevant context of extracted curriculum statements to minimize distortion and enhance transparency and reproducibility.

2.5 Ethical Considerations

Because the study involved no human participants and relied exclusively on publicly available or officially issued curriculum documents, informed consent and participant confidentiality were not applicable. No personal, confidential, or identifiable information was collected. Ethical practice was maintained through accurate representation of the source documents, appropriate attribution, preservation of the original curriculum wording, and transparent reporting of the coding and interpretation procedures. The researcher did not alter the curriculum documents and maintained an audit trail to support research integrity. No institutional review board approval was required for the documentary analysis because the study did not involve human participants or private personal data. Where required by the researchers' institution, the study's documentary nature and exemption from human-subjects review should be documented in accordance with institutional policy.

3. Results

Four patterns emerged from the selected MATATAG Science and K-12 Senior High School Earth and Space Science curriculum entries, which (1) Solar Power Is Represented Primarily Through the Broader Renewable-Energy Category; (2) Environmental Sustainability and Climate Action as Dominant Contexts; (3) Limited Evidence of Solar-Specific Technological Development; and (4) Solar Learning Progression Is Not Yet Explicitly Established. One of the key cross-cutting results was the explicit representation of solar power and contextual evidence. The Grade 7 entry on solar reference and the Grade 10 and Senior High School entries examined focused on renewable energy, climate change, energy conservation, and environmental effects. As a result, the latter items are not seen as evidence of instruction in PV or solar technology, but rather as contexts related to solar-power education.

Table 1. Document analysis matrix.

Document Title / Source	Grade Level / Subject	Content	Learning competency	Evidence type and representation	Analytic interpretation
CG- Science MATATAG Curriculum	G7 Q3/ force, motion and energy	Scientists and engineers conduct innovative research to find solutions to the current global energy crisis by seeking renewable energy solutions.	gather information from secondary sources to identify and describe examples of innovative devices that can be used to transform heat energy into electrical energy.	Indirect representation through renewable-energy solutions and heat-to-electricity conversion.	The competency provides context for examining renewable energy technologies that convert heat into electricity. Solar-thermal technology could be discussed as an example, but solar energy is not explicitly identified. Therefore, the evidence does not constitute direct solar-power instruction.
	G10 Q1/Earth and Space Science	The rich natural resources of the Philippines require sustainable management.	identify local impacts of global climate change and suggest ways that individuals can do to reduce the impact of global warming; and explain how increased societal uses	Indirect representation through renewable energy, climate change, and resource management. Renewable resources as a way to mitigate climate change	The competency establishes a relationship between renewable energy and climate change mitigation. Solar power may serve as an example of renewable energy, but the curriculum statement does not specifically identify solar technology. Thus, the evidence supports a broader

			of renewable energies could mitigate the effects of global climate change, including how the Philippines could make better use of its plentiful natural resources.		renewable-energy context rather than a solar-specific learning expectation.
	G10 Q2/ force, motion and energy	Renewable and non- renewable resources	collaborate in a class discussion to identify ways to reduce the use of electrical energy in Filipino houses and communities and explain what local and global benefits can be achieved; and gather information from secondary sources to evaluate how renewable and non-renewable generation of electricity in the Philippines impacts human activities and the environment.	Indirect representation through electricity generation and environmental/social impacts of energy sources. Presented as one of the sources of clean energy and it explain its impacts to human and environment	The competency provides an opportunity to examine different electricity generation sources and their environmental and societal impacts. Solar electricity can be considered within this broader category, but the competency does not explicitly require solar-generation technologies, system design, or solar-specific investigation.
SHS Earth and space science 1 Curriculum guide	Quarter 2	Energy sources (The differences between renewable and non-renewable energy sources are key to making	distinguish between renewable and non-renewable energy sources based on their characteristics, availability, use, and environmental impact; and	Indirect representation as a renewable energy source and through environmental impact and sustainability.	The content provides a general framework for understanding renewable energy and sustainable energy choices. Solar power can be situated within this category, but the competency does

		sustainable energy choices and reducing environmental impacts; and conserving energy sources and promoting sustainable practices are key to economic and environment sustainability)	use secondary sources to make a proposal for conserving energy sources to promote economic and environmental sustainability.		not explicitly establish photovoltaic technology, solar-energy conversion, or solar-system design as required learning..
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Table 2. Thematic analysis using the six-phase approach of Braun and Clarke (2006).

Phase	Analytical Procedure	Application and Decision Criteria in the Study
1. Familiarization with the data	The curriculum documents were read multiple times to grasp their content, structure, learning competencies and contextual meaning.	Pre-coding involved the researcher reading and analyzing the relevant curriculum statements and context for the identified grades 7 and 10, as well as SHS.
2. Generating initial codes	Relevant segments were systematically coded according to their meaning and relevance to the research objectives.	Solar power, renewable energy, energy transformation, electricity generation, technological application, sustainability, climate change, environmental impacts and energy conservation were all included in the codes. Explicit solar evidence was distinguished from broader renewable-energy evidence.
3. Searching for themes	Related codes were collated and compared to identify recurring patterns across the curriculum evidence.	Codes were grouped according to patterns in solar-power representation, environmental and sustainability contexts, technological development, and learning progression.
4. Reviewing themes	Candidate themes were examined against the coded extracts and the original curriculum context.	Themes were retained when they formed coherent patterns supported by the documentary evidence. General references to renewable energy were not treated as explicit evidence of solar unless solar power was directly identified.
5. Defining and naming themes	Each theme had a central organizing concept, scope and boundaries determined.	Four themes were defined as distinct patterns: (1) Solar Power Is Represented Primarily Through the Broader Renewable-Energy Category; (2) Environmental Sustainability and Climate Action as the Dominant Contexts; (3) Limited Evidence of Solar-Specific Technological Development; and (4) Solar Learning Progression Is Not Yet Explicitly Established.
6. Producing the report	The final themes were synthesized into an analytical narrative	Interpretations were linked to the relevant curriculum entries and limited to claims supported by the documents. An audit trail recorded extracted

	supported by documentary evidence.	statements, coding decisions, theme development, revisions, and final interpretations.
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Four themes emerged from the analysis. Themes are outlined below, along with excerpts from the curriculum and interpretations based on the documentary corpus.

Theme 1. Solar power is represented primarily through the broader renewable-energy category.

Theme	Description
Solar Power Is Represented Primarily Through the Broader Renewable-Energy Category	Solar power was indirectly represented through broader aspects of the curriculum, such as renewable energy solutions, energy conversion, electricity, and energy sources.

The first is the most overarching and persistent trend in the data. Solar energy is primarily classified under the broader category of renewable energy. Solar energy can be introduced in the curriculum in several places; however, in the analyzed competencies, the terms used are mostly tied to renewable energy, energy resources, or energy conversion. In Grade 7, the curriculum asks learners to gather information about innovative devices that convert heat energy into electrical energy and situates this learning within the search for renewable-energy solutions. This is a valuable opportunity for solar examples, especially technologies that use solar heat or electricity. However, the competency does not explicitly refer to solar power, PV cells, or solar panels, so it should be understood as an indirect rather than a direct solar reference. In Grade 10, renewable energy is tied to climate change mitigation, sustainable management of Philippine resources, electricity consumption, and the impact of electricity generation on people and the environment. The contexts are significant for solar power because there is a scenario in which solar electricity can be integrated with other renewable energy sources.

Nevertheless, the competencies are written at a more general level in the field of renewable energy. This is also seen in Earth and Space Science 1 in Senior High School, where renewable and non-renewable sources are discussed based on their features, availability, applications, and environmental impacts. Solar power is included in this classification, but the curriculum statement does not mandate studying photovoltaic systems or solar engineering. All the evidence indicates that the selected curriculum serves as a structural basis for solar power learning, but not as a separate curricular strand. The difference should be noted: the curriculum enables solar learning, but the analyzed entries do not make it explicit.

Theme 2. Environmental sustainability and climate action are the dominant contexts.

Theme	Description
Environmental Sustainability and Climate Action as the Dominant Contexts	Solar power is framed between renewable-energy learning and the concepts of climate change, sustainable resource management, environmental impacts, conservation, and the social goals of energy choices.

This theme summarizes the dominant conceptualization of solar power in the curriculum as a means of contributing to environmental sustainability and climate action. Solar energy may be included in a Grade 7 inquiry into renewable-energy solutions to the global energy crisis, especially through technologies that convert heat into electricity. The link is closer in Grade 10 Quarter 1 as renewable energy is taught as a way to address climate change, mitigate global warming, and sustainably utilize the Philippines' natural resources. As a renewable energy source, solar power can be viewed as one possible solution to these environmental issues. Solar power is introduced as an alternative source of clean energy in Grade 10 Quarter 2, while its effects on human activities and the environment are considered. Solar energy is also considered a renewable energy source at the SHS level and is explored alongside issues of energy conservation, sustainable energy, and environmental impacts. Taken together, these findings reveal that the relevance of solar energy in the curriculum tends to be focused on approaches that address energy challenges, reduce environmental impacts, contribute to climate change mitigation, conserve energy resources, and foster sustainable energy use.

Theme 3. Limited evidence of solar-specific technological development.

Theme	Description
Limited Evidence of Solar-Specific Technological Development	Selected competencies lay foundations for energy conversion, information gathering, explanation, evaluation, and conservation, but do not specifically establish photovoltaic-system knowledge, solar-resource analysis, or solar-specific engineering design.

This theme is about how extensively the curriculum explores solar power as a system of science and technology. Results indicate that learners acquire general skills that can be applied to understanding an energy technology, such as data collection, energy conversion, assessment, and conservation. Students should gather data on innovative technologies that convert heat energy into electrical energy in Grade 7 as a conceptual basis for understanding solar-thermal technologies. In Grade 10, the use of renewable and non-renewable energy sources for electricity generation is compared, and the effects of these on humans and the environment are explored, providing an opportunity to incorporate solar power plants into electricity generation. At the Senior High School level, students describe the differences between renewable and non-

renewable energy sources in terms of their properties, availability, and uses; discuss the environmental effects of renewable and non-renewable energy sources; and develop ideas about conserving energy. The following skills provide a general technological foundation for understanding energy systems. The overall curriculum, however, does not provide much explicit evidence of competencies specifically focused on solar power technologies. There is little indication of learning experiences involving photovoltaic systems, assessment of solar resources, examination of solar-system components and performance, or the design, testing, and evaluation of solar-power systems. Therefore, the potential of solar energy is best understood as an example or application of broader energy and sustainability issues rather than as a separate technological system to be investigated and developed. The curriculum, therefore, does not provide a strong basis for a discussion of energy technologies, and it shows little evidence of the development of technological knowledge and processes that are progressive and solar-specific.

Theme 4. Solar learning progression is not yet explicitly established.

Theme	Description
Solar Learning Progression Is Not Yet Explicitly Established.	The learner actions become more demanding across the selected entries, progressing from gathering and describing to explaining, evaluating, distinguishing, and proposing; however, the documents do not present a continuous, solar-specific conceptual sequence.

The theme indicates the degree of progression in learning about solar power at the chosen curriculum levels. The data show that the skills the learner is expected to demonstrate are becoming more complex. Grade 7 students should be able to obtain data from secondary sources and recognize and describe some innovative devices that convert heat energy into electrical energy. During Grade 10 Quarter 1, students explore ways in which renewable energy can help to reduce climate change. During Quarter 2 of Grade 10, students assess the impact of renewable and non-renewable electricity generation on human activities and the environment. At the SHS level, learners differentiate between renewable and non-renewable energy sources and suggest ways to conserve energy sources for economic and environmental sustainability. The learning actions shift from collecting information to identifying and describing to explaining, evaluating, and proposing across these levels. This growing complexity, however, is largely at the highest energy and renewable energy levels, not in a clearly defined series of solar-specific learning steps. The curriculum does not regularly make links that would lead to the development of solar knowledge from basic to more specific knowledge of solar technology and application. The results, therefore, suggest a general trend toward increasing complexity in energy-related learning actions, but not a clearly sequenced progression of knowledge and the application of solar energy.

Solar learning progression within the selected curriculum levels is therefore not yet explicitly established.

4. Discussion

The results indicate that the problem is not that solar energy is not part of the Philippine science curriculum, but that the positioning, development, and integration of solar energy in the curriculum are. The concepts of solar energy apply to renewable energy, energy transformation, electricity generation, environmental sustainability, and energy conservation. But these representations do not always become a coherent body of solar-specific scientific and technological knowledge. This pattern appears through the lenses of energy literacy, interdisciplinary STEM learning, and learning progression. It indicates that while the curriculum offers important groundings, it may not be impacting learners' progression from seeing solar energy as a renewable energy to seeing, assessing, and applying solar technologies.

The predominance of the broader renewable-energy category has implications for the depth of learners' energy literacy. Energy literacy is not just about recognizing that renewable energy is better for the environment; it's about understanding how energy is produced, converted, consumed, stored, and linked to environmental and social impacts (Hoque et al., 2022; Santillán & Cedano, 2023). If solar power is the first and most familiar example of renewable energy, learners might be able to develop a general understanding of renewable energy without gaining more detailed conceptual knowledge of solar energy systems. The curricular gap is not just a lack of solar references but also a disconnect between energy awareness and increasing solar-energy literacy.

The distinction is especially significant because solar energy is based on scientific principles that go beyond the mere classification of an energy source. It is helpful to understand solar technologies in terms of connections between solar radiation, energy transfer and transformation, electricity, efficiency, technological systems, and environmental implications. The lack of focus on PV systems, solar energy resources, system components, system performance, and technological design may limit learners' opportunities to build competence in scientific explanation, technological analysis, evidence-based evaluation, and engineering design. This interpretation aligns with existing literature that states that solar energy is an interdisciplinary context for STEM, and the incorporation of scientific knowledge and skills into STEM is linked to technological, mathematical, engineering, and problem-solving skills (Amalu et al., 2023; Shahbazloo & Mirzaie, 2023; Sung et al., 2024; Tang et al., 2026). This means the curricular gap can affect what learners are ready to do with their learning, rather than what they can remember about renewable energy.

The environmental and climate-action approach to solar power is a positive aspect of the curriculum, as it connects energy learning to real societal issues. If the focus is on environmental significance and there are no other contexts that allow learners to examine the technologies in terms of mechanism and performance, learners

may be primed more to receive sustainability messages than to develop into participants able to critique energy technologies. This is relevant to energy literacy, which involves understanding and informed use of energy, enabling sound decision-making regarding energy generation, consumption, efficiency, and environmental effects (Santillán & Cedano, 2023). A more robust treatment of the curriculum should therefore link the environmental need for solar energy to the opportunity to explore why some solar technologies are effective and under what conditions they may be effective, what their limitations are, and how their performance can be determined.

One additional concern is the lack of a clearly defined learning progression for solar learning. Some ideas may serve as stepping stones to deeper understanding within the curriculum, but there is no evidence of a logical progression of ideas across levels. As a learning-progressions phenomenon, fragmentation can hinder a learner's ability to connect basic concepts of solar energy, heat, light, and electricity with more advanced concepts of solar energy systems. Nordine et al. (2018) call for linking energy ideas across phenomena and disciplinary contexts to enable students to use conceptual knowledge as a whole, rather than learning about related but unconnected concepts. Similarly, the repeated use of energy across different levels of education does not guarantee the progressive development of thinking, as shown by Markóczi Revák et al. (2023). It is also important to note that, in this context, multiple exposures to renewable energy cannot be considered evidence of a coherent solar-power learning sequence.

As students progress through the education system, these may manifest as competency gaps. Learners might encounter opportunities to identify renewable energy sources, describe environmental impacts, compare energy sources, and discuss energy conservation, but receive fewer opportunities to explain the operation of solar technologies, interpret solar-energy data, assess system performance, evaluate technological choices, and engage in solar-related engineering design (Kandpal & Broman, 2014; Nik Abdul Majid et al., 2025). The distinction is relevant because the latter skills are application-, analysis-, evaluation-, and design-oriented and are more aligned with the interdisciplinary nature of today's solar technologies (Amalu et al., 2023; Shahbazloo & Mirzaie, 2023). Rather than learners being unable to demonstrate the energy competencies, the problem lies in the fact that the curriculum might not always offer the progression required to develop the general energy knowledge into the more specific, solar-specific, scientific, and technological competence (Kandpal & Broman, 2014; Nik Abdul Majid et al., 2025).

The impact is not limited to individual achievement; it also becomes relevant to institutional capability and competitiveness in the international arena. Educational institutions, in the context of a country's transition to a more sustainable and technologically advanced energy system, are expected to play a role in developing learners who can access and understand emerging technologies, interpret evidence, solve complex problems, and engage with innovations (Amalu et al., 2023; Kandpal & Broman, 2014). A disjointed approach to solar power could hinder schools' ability to systematically develop these skills and competencies as part of their foundational

science curriculum, and then progress to STEM and engineering applications (Nik Abdul Majid et al., 2025; Shahbazloo & Mirzaie, 2023). Inadequate curricular articulation can, over time, lead to misalignment between the skills acquired in general education and the competencies expected of students in the scientific, technological, and problem-solving aspects of new green economy industries (Amalu et al., 2023).

In the Philippines, this is especially pertinent to the nation's renewable-energy goals. A curriculum that promotes awareness of renewable energy topics but offers limited potential for further exploration and development of skills for innovativeness and technology use may help build general energy awareness and not equip learners to develop specific skills and competencies in the field (Kandpal & Broman, 2014; Nik Abdul Majid et al., 2025). Global competitiveness goes beyond developing specialists in basic education; it also means providing an educational foundation from which students can build toward STEM participation, technological innovation, and informed participation in emerging industries (Amalu et al., 2023). In that regard, enhancing solar-power representation can help build energy literacy and equip the future energy workforce – which will be increasingly complex – to connect with it (Amalu et al., 2023; Nik Abdul Majid et al., 2025). The results, therefore, identify a curricular opportunity rather than a curricular deficit. Current renewable-energy and sustainability skills can be built upon to create a more clearly defined solar-power learning pathway (Kandpal & Broman, 2014). This could evolve from basic concepts of energy into energy from the sun and energy conversion, producing electricity, solar and PV systems, system performance and efficiency, environmental and socioeconomic assessment, and finally energy system engineering design and application (Amalu et al., 2023; Shahbazloo & Mirzaie, 2023). This would maintain the current focus of the curriculum on sustainability and broaden learning to include the scientific and technological skills needed to appreciate and assess solar power systems (Nik Abdul Majid et al., 2025). This would align with the philosophy that solar-energy education should offer opportunities not only to identify the importance of renewable energy but also to explain, investigate, evaluate, design, and use knowledge in meaningful contexts (Kandpal & Broman, 2014; Shahbazloo & Mirzaie, 2023). In general, the theoretical value of the results is that the presence of a curriculum does not mean that it has been developed. Solar energy is evident in the context of renewable energy and sustainability, but it is a relatively small and underdeveloped scientific and technological learning area. This broader framing of renewable energy, coupled with more robust environmental contextualization, less technology-specific to solar energy, and an implicit progression pathway, can help foster basic energy literacy without necessarily developing more advanced solar energy skills (Nik Abdul Majid et al., 2025). This gap might be mitigated by better linking basic science education to STEM learning and knowledge and skills needed to engage in a rapidly evolving sustainable-energy landscape (Amalu et al., 2023; Shahbazloo & Mirzaie, 2023).

5. Conclusion

This study analyzed the curricular representation of solar energy in selected Philippine science curriculum documents and found it relevant but scattered throughout the documents. In all four curriculum entries analyzed (one grade 7, two grade 10, and one from senior high school), solar energy was predominantly depicted within the broader frameworks of renewable energy and sustainability. Four patterns were identified during the analysis: Solar Power Is Represented Primarily Through the Broader Renewable-Energy Category; Environmental Sustainability and Climate Action as Dominant Contexts; Limited Evidence of Solar-Specific Technological Development; and Solar Learning Progression Is Not Yet Explicitly Established. The results show that opportunities for energy and environmental learning exist in the curriculum, but are not yet explicit enough to lead to greater understanding of and technical skills with solar energy.

The presence of a solar power topic in the curriculum does not necessarily imply that it has been developed. Learners can be introduced to renewable energy concepts, energy conversion, electricity production, environmental impacts, and energy conservation, but do not always receive systematic opportunities to discuss solar technologies, interpret solar energy data, analyze system performance, or design-oriented applications. As a result, the current curriculum can serve as scaffolding for energy literacy. Still, its fragmented representation may not fully facilitate the shift from environmental awareness to the scientific, technological, and engineering skills involved in solar energy systems. This is especially significant as energy literacy is about having an informed understanding of energy technologies, not only renewable energy.

The results suggest that, instead of simply increasing solar energy content, educational policymakers need to focus on curriculum articulation. Firstly, the four identified curriculum entries provide a foundation for promoting the representation of solar power without introducing it as a standalone subject. Existing renewable energy competencies can be scaled to grade levels to ensure a clear progression from basic to more advanced competency applications. Second, a curriculum should specify specific competencies in the solar area that are currently underrepresented, such as PV and solar thermal principles, solar resource interpretation, system components, efficiency and performance evaluation, and solar technology design. Third, the environmental sustainability competencies should be intentionally integrated into technical learning tasks, thereby raising awareness of the importance of renewable energy and exploring the operation and evaluation of solar technology and its limitations.

One way to combine the two is to integrate solar energy education into other science and STEM skills. Basic instruction on heat, light, and energy conversion can lead to teaching about electricity generation and the principles of photovoltaics. These concepts can then be linked to data interpretation, efficiency analysis, comparison of solar technologies and suitable engineering design activities. This articulation would represent a shift from sustainability as a mostly contextual theme to sustainability as a

context for scientific research, technology evaluation, and engineering problem-solving. It is consistent with the interdisciplinary nature of solar energy and with the role of STEM education in developing students' capacity to apply scientific knowledge to real-world technological problems.

As a result, four actions are recommended for curriculum policymakers and developers. First, existing renewable energy competencies should be mapped against the four identified curriculum entries to determine where solar-specific learning can be made explicit. Second, the solar competencies should be progressively sequenced from conceptual understanding to investigation, evaluation, and design. Third, learning resources and teacher support for the curriculum should be built around photovoltaic and solar thermal technologies, system performance and evidence-based evaluation. Fourth, there should be indicators to measure curriculum implementation that separate general renewable energy awareness from specific scientific and technological competencies related to solar energy. These actions would enable the curriculum to maintain its strong sustainability focus while enhancing its technical focus and continuity of learning about solar power.

The results showed that the conceptual underpinnings of the Philippine science curriculum are in place for the development of a stronger solar energy learning pathway, which, however, must be elaborated and articulated in greater detail, with greater technological richness, and with stronger vertical articulation. Developing this pathway would enable students to build a sequence of skills that would move them from awareness of the environmental benefits of using renewable energy to understanding, exploring, assessing, and designing solar energy applications. Through this, solar power education can enhance energy literacy and interdisciplinary STEM development, and prepare learners for involvement in a sustainable, increasingly technology-driven energy economy.

Acknowledgment

The researchers sincerely thank Almighty God for His guidance and strength, as well as their families, friends, colleagues, and all individuals whose support and encouragement contributed to the completion of this study.

Conflict of Interest Statement

The authors declare no conflict of interest.

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Author Contributions: Racuya, G. F.; Lagura, R.; Conceptualization, study design, methodology, data collection, data analysis and interpretation, and manuscript preparation. Both authors have read and approved the final version of the manuscript and agreed to be accountable for the integrity and scholarly content of the work.