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Towards a Learning Progression of Alternative Energy at School: A Literature Review

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Abstract: The enormous energy crisis due to the high demand for energy consumption leads to the need to incorporate Sustainable Development Goals (SDGs) into the learning strategy to ensure energy-literate citizens. This study addressed the analysis of the current trends of alternative energy education in the school setting in terms of educational level scope, content area, and educational strategy. The data was gained from the Scopus database and the PRISMA method which includes the identification, screening, and inclusion phase was used. 15 articles were brought to the inclusion phase to be read and analyzed. The result highlighted that the educational level covered in alternative energy education mainly focused on secondary and university levels. It is found that at elementary and high school levels, there are insufficient amounts of alternative energy education happened. Most of the papers covered general alternative energy as the topic and the rest of the articles mainly focus on one type of alternative energy topic. Project-based learning was the most common educational strategy in teaching alternative energy and STEM learning comes as the second common. Pedagogical, professional development, problem-based learning, and virtual lab were also utilized to teach alternative energy.

Keywords: Alternative Energy; Educational Strategy; Sustainable Development Goals (SDGs)

Introduction

The world is confronted with an enormous energy crisis due to global energy consumption. Fast-expanding worldwide population, and the reliance on fossil fuels for power generation and transportation, leading to the overuse of petroleum and gas depletes natural resources while increasing carbon dioxide emissions, resulting in higher global temperatures (Bhan et al., 2020). Concerns over the depletion of resources, particularly coal and oil, as well as the environmental and atmospheric pollution they create, have fueled interest in the utilization of clean, alternative energy sources (Çakirlar Altuntaş & Turan, 2018). The utilization of alternative energy sources may assist in lowering energy prices, improving air quality and human health, and generating employment (Adebayo et al., 2023). The goal of living on a sustainable planet strongly depends on the education of future citizens in the values of sustainability and respect for the environment (García-Ferrero et al., 2021).

The United Nations established September 2015 as a worldwide scheme of action for people, the environment, and the economy (Santika et al., 2020). Among the 17 SDGs, SDG number 4 states "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", and SDG number 7 states "Ensure access to affordable, reliable, sustainable and modern energy for all" are the major driving forces behind this article (García-Ferrero et al., 2021). The persistent gap between the achievement of SDG 8 (clean and affordable energy) and SDG 13 (climate action) reflects the poor uptake of renewable energy solutions across the nations (Zafar et al., 2020a). Low involvement in research and development activities can be linked to inadequate educational attainment, which may harm the environmental quality in two distinct ways, i.e. it may limit the opportunities to

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discover alternative energy and it may limit the dissemination of environmental awareness among the citizens (Collins & Gannon, 2014).

Education is critical in creating knowledge and changing attitudes toward energy conservation and the usage of renewable energy sources for the sustainable development of society (Ocetkiewicz et al., 2017). In addition, education may be utilized to foster energy education for consumers and businesses to generate and embrace diverse renewable energy sources (Mahalik et al., 2021). Learning how energy-generating systems function, their benefits and drawbacks, and how to improve them would most certainly lead to the creation of a sustainable society (García-Ferrero et al., 2021). When students receive environmental education that focuses on their cognitive, affective, and psychomotor abilities, it is envisioned that they will engage in positive and permanent behavioral modifications in terms of conserving the environment and natural resources, and thus take an active role in problem-solving (Çakirlar Altuntaş & Turan, 2018). Education can influence energy consumption not solely through its relationship with economic growth, but also through consumer decisions to consume specific products that primarily utilize pollution-intensive energies or pollution-free energy-efficient products, technologically advanced, adaptation with new technologies, and fuel substitution (Mahalik et al., 2021).

Shidik & Tae (2022) obtained a conclusion that there was still a large portion of students who had misconceptions about the topic of Energy. This was caused by the lack of students' understanding of the topic of Energy. 55% of students feel they face limitations in understanding materials related to renewable energy. Additionally, 85% of physics teachers express concerns about students' difficulties in grasping the concept of renewable energy (Chairunnisya et al., 2023). The level of knowledge and understanding about alternative energy sources based on biofuel in the community is still relatively low (Anggereini et al., 2023). Research shows that it is possible to become aware of threats to the environment and that sensitivity to environmental problems can be taught through formal education (Uzun & Yıldırım, 2018). García-Ferrero et al., (2021) highlight that practical applications and real-life-based projects as well as performance work can help to contextualize energy concepts in the school curriculum to increase awareness of environmental issues. Utilizing the appropriate learning strategy to teach the concept of alternative energy can maximize the learning outcome to create energy-literate citizens. Therefore, this research aims to analyze the current trends of alternative energy education in the school including the educational level, content area, and educational strategy.

Method

To address the aim of this paper, the PRISMA method was used. Relevant and high-quality articles were selected to allow comprehensive analysis of the perspectives of different researchers/authors and combine them to answer specific questions, as well as identify research gaps in the field (Hoque et al., 2022). The PRISMA method in this research includes the identification and screening phase, resulting in the final number of articles that were included. The flowchart can be seen in Figure 1.

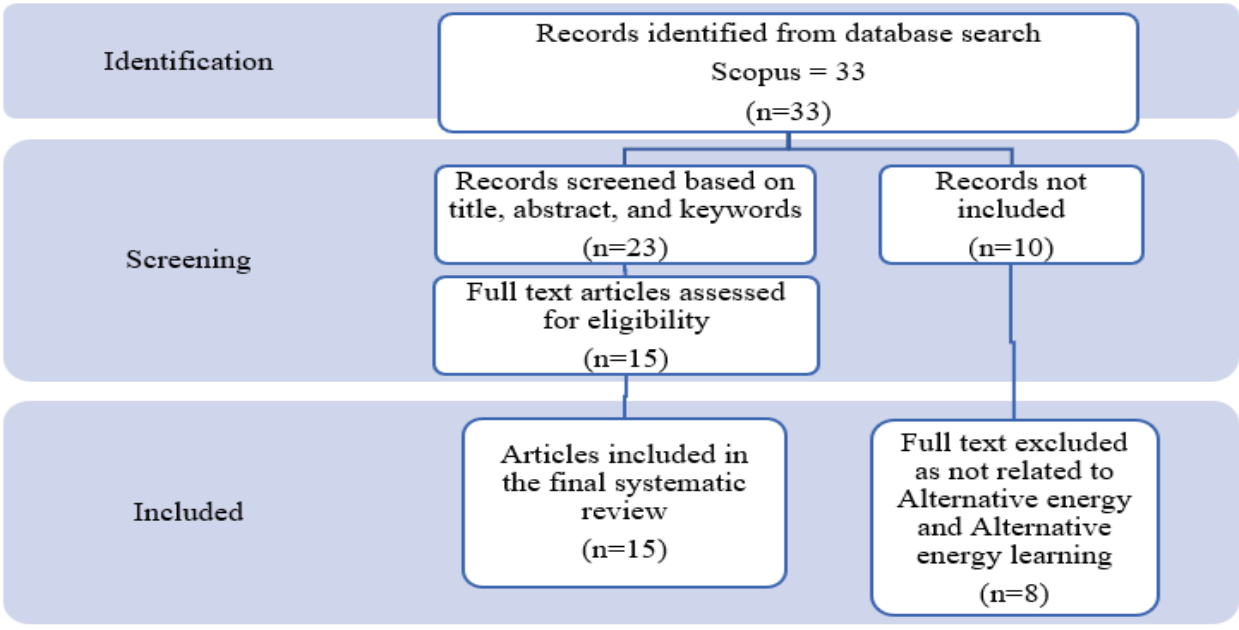

Figure 1. PRISMA Flowchart

The identification phase includes 33 articles that were found in the Scopus database with the search string TITLE-ABS-KEY (("Alternative Energy") AND ("Education")). The next phase is screening. In this phase, the author selected the article manually by analyzing the title and abstract. A total of 10 articles were removed from the data. The inclusion phase involved reading and analyzing the articles thoroughly to find the authors' perspectives, results, and opinions regarding the topic. The total of articles included in this research is 15 articles. The summary of the selected articles is shown in Table 1.

Table 1. Review Summary of The Articles

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
Aadu Ott∗, Lars Broman, Konrad Blum	A pedagogical approach to solar energy education	- Could renewable energy education be enriched by creating links to the socio–cultural theory of learning and to educational neuroscience or by being framed within an Innovative Learning Environment, according to how this concept has been developed and presented by OECD? - Does implementation of renewable energy systems and/or education in our society imply Revolution, Evolution, Enrichment, or Provocation education in or utilization of traditional energy resources?"	General	Neuroscience approach	Grounded theory	- The introduction of renewable energy education, to a certain extent, could gain by regarding a discussion of problems with resistance emanating from aspects such as revolution, evolution, enrichment, or provocation of established educational approaches for teaching and learning about traditional energy conversion processes. -It is fruitful to make a "quantum jump" in renewable energy education from "hard" discourses such as science and mathematics to more "soft" discourses like sociology of science, psychology of the mind, and neuroscience of the brain
Simson, A., & Davis, B.	A sustainability and alternative energy course as a bridge between disciplines	To assess of a new interdisciplinary course on sustainability and alternative energy offered to Art, Architecture, and Engineering students at The Cooper Union, a small, primarily undergraduate institution	University	Course Development (Project assessment)	Survey study	- Student interest in all topics increased during the semester. - Student survey responses were overwhelmingly positive students enjoyed the diverse cohort and set of topics, the focus on group work and active discussion via Zoom, and the projects (on a specific renewable electricity generation site and a life cycle assessment). - Survey results show that Engineering students were initially more interested in course topics related to technology whereas Art/Architecture students were more interested in course

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
						topics related to cultural and political issues; however, after the course, student interest in these topics converged and there were no discernable difference in interest levels across course topics between the two cohorts. We show that students gained an increased appreciation for (and understanding of) both the science/technology and ethical trade-offs in energy system choices. - Our assessments (via remote oral presentations, online quizzes, electronic homework, and recorded videos) found that students, regardless of discipline, met course learning objectives despite the limitations of a remote format.
Chen, C.-S.; Lin, J.-W. An	An action research on the long-term implementation of an Engineering-centered pjbl of sustainable energy in a rural Middle school	1. How will the designed engineering-centred PjBL of sustainable energy be adequately implemented in the rural school during the 2015–2018 school years? 2. How does engineering-centred PjBL of sustainable energy influence students' development of creativity and engineering technical skills in the Makers Club? 3. How does engineering-centred PjBL of sustainable energy enable rural students to turn the concept of green energy sustainability into action and enhance their learning attitude?	Junior High School	Engineering-centered PjBL of sustainable energy curriculum	Practical action research	- The students in the Makers Club improved their engineering technical skills and created various green-power generation devices (evolved from a ventilation ball generator, hydropower, and ocean current power generators to tiny, 3D-printing wind power generators).
László Berényi, Nikolett Deutsch	Assessment of the future role of some energy sources by higher education	This paper summarizes an experiment among Hungarian higher education students to analyze their opinion about renewable and nuclear energy sources	higher education		Survey design	- The respondents are optimistic about favorable future changes in the utilization of renewable energies. solar power and wind power are considered decisive and acceptable sources.

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
	students in hungary					There is a general distrust of nuclear energy among the respondents - The evaluations confirm a positive approach to sustainability and a particular emphasis on solar power. The result shows the need for knowledge formation that the assessment of the future role is not in line with the professional opinion and the national strategy.
Benitz, M.A.; Yang, L.-L.	Bridging education and engineering students through a wind energy-focused community engagement project	To describe and measure the impacts of the implementation of three years of a cross-disciplinary community engagement project, connecting students in engineering and education courses, as a tool for teaching about wind energy, engineering design, and science education	Undergraduate student	PjBL Course development : One day of professional development , five classroom lessons, celebration event (project presentation)	Pre-experimental (based on context)	- Analysis of responses from the Teaching Engineering Self-Efficacy Scale and an end-of-semester course survey demonstrate growth in student learning and transferrable skills from participating in the semester-long project. - Exploration of students' narrative work provides a richness to further understanding of their growth and the challenges they confronted.
Ona Egbue, Suzanna Long, Ean-Harn Ng	Charge it! Translating electric vehicle research results to engage 7th and 8th grade girls	To develop a workshop that aims to promote knowledge building in the area of sustainability and alternative energy use in transportation and to stimulate greater interest in STEM subjects	Junior High School	STEM, Workshop	Qualitative	- Early exposure to Meaningful engineering experiences for these young girls may boost interest and the eventual pursuit of engineering and technology education paths. - Students had a clearer understanding of the engineering profession and a strong understanding of the basic concepts of electric vehicles. They also understood the geographic implications of the technology, particularly those materials (in this case lithium) that are sourced from various parts of the world. The participants seemed more confident in their responses to questions about electric vehicles and most were

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
						able to correctly name three or more countries that had lithium reserves and resources.
Travis P. Wagner1 & Kelly McCormick 2 & Daniel M. Martinez1	Fostering stem literacy through a tabletop wind turbine environmental science laboratory activity	To develop a hands-on laboratory activity for an introductory environmental science course that uses tabletop wind turbines designed to improve students' STEM and energy literacy and to introduce them to the science and technology of wind energy and basic land use considerations of siting wind farms	Undergraduate	STEM	Qualitative	- This lab engages students, most of whom are not STEM majors; supports their ability to solve a real, hands-on integrated STEM problem; and increases their understanding and ability to communicate about the scientific and technical aspects of energy, in particular wind energy.
Maurisete Fernando Ferreira, Marcos Aurélio Vasconcelos Freitas, Neilton Fidelis da Silva, Antonia Francimar da Silva, and Luciana Rocha Leal da Paz	Insertion of photovoltaic solar systems in technological education institutions in brazil: teacher perceptions concerning contributions towards sustainable development	to evaluate teacher perceptions regarding the presence and influence of the adoption of the photovoltaic solar systems in the pedagogical practice at school, in the teaching–learning process and in the difusion of the premises of sustainable development in the teaching spaces.	University	- (perception)	Qualitative (survey)	- Teachers are aware of the importance of these sources, but their knowledge does not form links with their practice. Thus, the necessary connections to promote sustainability from the existence of institutional photovoltaic systems were proven insufficient. They did not support the concept, nor the adoption of pedagogical practices linked to this technology. - In addition, the teacher's inability to bring knowledge related to renewable energies to the classroom and link them to daily student lives was also noted. The adoption of renewable energy to promote a sustainability culture demands the formation of teacher knowledge and attitudes, and this training must follow a continuous path.
Eileen G. Merritt, Nicole Bowers, Sara E. Rimm-Kaufman	Making connections: elementary students' ideas about electricity and energ resources	To explores energy literacy development in fourth-grade classrooms	Elementary students Fourth grade	Service-learning Professional development Discovery learning (based on	Qualitative	- Students were familiar with solar, hydropower and wind energy, and suggested that solar energy should be used more in the future. Students were more easily able to explain energy transfer in wind turbines and solar panels than in other electricity

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
				the literature)		production systems. Students learned important energy and natural resource concepts in the context of a service-learning program.
Suyatman - Sulistyo Saputro - Widha Sunarno Sukarmin	Profile of student analytical thinking skills in the natural sciences by implementing problem-based learning model	To analyze the student's analytical thinking skills in the natural sciences, particularly in new and renewable energy.	High School	Problem-based learning	Sequential explanatory design	- Analytical thinking skills in the concept of new and renewable energy in the experimental group were higher than in the control group. - Innovative learning like PBL had the potential as an alternative method to increase the analytical thinking skills of students.
Rafael Pastor, Llanos Tobarra, Antonio Robles-Gomez, Jesús Cano, Bashar Hammad, Abdullah Al-Zoubi, Roberto Hernandez, Manuel Castro	Renewable energy remote online laboratories in jordan universities: tools for training students in jordan	To analyze the incorporation of remote/virtual laboratories, showing how these labs were developed/integrated into online courses.	University	Virtual laboratory	Structural equation model (SEM), experimental	- The use of remote and virtual laboratories improves the perception and use of virtual environments at a distance. Also, it can be indicated that these laboratories are presented as an essential resource to improve the quality of online teaching in engineering courses.
Fahimul Hoque, Ruhizan M. Yasin, and Kamaruzzaman Sopian	Revisiting education for sustainable development: methods to inspire secondary school students toward renewable energy	To analyze the current trends of existing education in RE concepts and education for sustainable development (ESD) in secondary schools	Secondary school	(SLR)	SLR	- Positive impacts of introducing certain Retargeted ESD courses/activities on students. Thus, we propose adopting new methods that include collaborative multidisciplinary and informal and non-formal and other factors as a means toward arousing secondary students' interest in AE education to achieve the SDGs.
Rosemary N. Wojuola, Busisiwe P. Alant	Sustainable development and energy education in nigeria	To explore the beliefs, perceptions, and attitudes of the Nigerian public to renewable energy technologies so as to derive implications for science and technology policy and education in the country	All level	(survey)	Sequential mixed-method	- There is also no relationship between the educational level of the participants and their knowledge of renewable energy technologies. The majority of the participants were not aware of sustainable

Author(s)	Title	Research Aim	Educational Level	Educational Strategy	Research Method	Findings
						development. The outcome of this study underscores the need to widen the nation's science and technology policies as well as its educational curriculum to incorporate themes addressing renewable energy and sustainable livelihood.
I. Wilujeng, W. S. B. Dwandaru, R. A. Binti A. Rauf	The effectiveness of education for environmental sustainable development to enhance environmental literacy in science education: a case study of hydropower	To analyze the effectiveness of learning using EESD-based student worksheets to improve environmental literacy.	Junior High School	Education for Environmental Sustainable Development (EESD)	Quasi-experiment	- ESD-based student worksheets are useful to improve students' environmental literacy
Irene Poh-Ai Cheong, Marliza Johari, Hardimah Said & David F. Treagust	What do you know about alternative energy? Development and use of a diagnostic instrument for upper secondary school science	To develop a two-tier instrument to diagnose students' understanding and alternative conceptions about alternative energy in terms of: sources of alternative energy, greenhouse gas emission, as well as advantages, and disadvantages	Secondary school	(instrument development)	Qualitative and quantitative methods	- Students' understanding of alternative energy was low (M ¼ 7.03; SD ¼ 3.90). The 23 alternative conceptions about alternative energy sources that could be identified from the instrument are reported.

Result and Discussion

Educational attainment might have an environmental impact, which can be realized in renewable energy generation (Zafar et al., 2020b). Energy generation has a major impact on climate change. Therefore, there is an increasingly urgent need to include energy-related topics in contemporary education programs (Nowotny et al., 2018). To achieve sustainability and improve the quality of the environment, it is essential to use renewable energies and energy efficiency measures that ultimately will reduce energy consumption and air pollution. It is also important for governments, businesses, organizations, colleges, and universities to enact policies that incorporate practices and technologies that are designed to promote sustainability (Msengi et al., 2019). Education is critical in creating knowledge and changing attitudes toward energy conservation and the usage of renewable energy sources for the sustainable development of society (Ocetkiewicz et al., 2017). There were 15 articles analyzed in terms of alternative energy education. The result is categorized into three sections that include 3 areas; based on educational level, content area, and educational strategy.

Educational level

Alternative energy education was supposed to be integrated into all levels of education. This section aims to analyze the educational level covered in the 15 articles. Research by Ott et al., (2018) and Wojuola & Alant, (2019) analyzed the alternative education energy as a general education without considering its educational level. Alternative energy education at the

elementary level was carried out by Merritt et al., (2019) and stands as the only research done in elementary school among the 15 research. In secondary school, there are 5 research done by Chen & Lin (2021), Egbue et al. (2015), Hoque et al. (2022), Wilujeng et al. (2019), Cheong et al., (2015). Suyatman et al. (2021) carried out the research in a high school and the only one done at this school level. Alternative energy education in Universities holds the higher number of research with 6 papers done by Benitz & Yang, (2021), Berényi & Deutsch (2020), Ferreira et al. (2020), Pastor et al. (2020), Simson et al. (2022) and Wagner et al. (2017).

Education may also prepare the youth with the requisite knowledge and moral responsibility needed to better understand and solve environmental problems, especially those related to energy generation (Ocetkiewicz et al., 2017). The result highlighted that alternative energy is quite common at secondary and university level, but uncommon for elementary and high school. This might lead to the conclusion that early education for elementary school students in alternative energy was more needed. This is in line with Ocetkiewicz et al. (2017) who found out that lower secondary school teachers are not well prepared to put key issues of sustainable development in the school curricula into practice. Teachers do not know the educational principles behind sustainable development, nor their priorities and the objective of promoting a better and multifaceted understanding of the issues that the civilization faces. Integrating alternative energy in the early education phase may result in a more sustainable society.

Content area

Alternative energy as a learning content might be too broad to be taught as a whole content. Therefore, most of the teachers might choose one of the alternative energy types as the representative. There are wide types of alternative energy known, the most-known types include solar energy, wind energy, and hydro energy. Among 15 papers, the content area included in the research was analyzed. 8 papers took the general topic of alternative energy, such as research by Berényi & Deutsch (2020), Cheong et al. (2015), Hoque et al. (2022), Merritt et al. (2019), Pastor et al. (2020), Simson et al. (2022), Suyatman et al. (2021), and Wojuola & Alant (2019). Research by (Simson et al., 2022) provides a course on sustainability and alternative energy. Survey results show that Engineering students were initially more interested in course topics related to technology whereas Art/Architecture students were more interested in course topics related to cultural and political issues; however, after the course, student interest in these topics converged and there was no discernable difference in interest levels across course topics between the two cohorts. Another research (Berényi & Deutsch, 2020), analyzes students' opinions about renewable and nuclear energy sources in Hungary. The respondents are optimistic about favorable future changes in the utilization of renewable energies. Solar power and wind power are considered decisive and acceptable sources. Meanwhile, there is a general distrust of nuclear energy among the respondents.

The exploration of elementary students' energy literacy was done by (Merritt et al., 2019) by using a questionnaire. The result indicates that the students were familiar with solar, hydropower, and wind energy, and suggested that solar energy should be used more in the future. Students were more easily able to explain energy transfer in wind turbines and solar panels than in other electricity production systems. Revák et al. (2019) highlight that in general, solar, water, and wind energy resources have been the most well-known ones among students in primary, secondary, and higher education, and geothermal energy and biogases, for example, have been less known to them. Meanwhile, one of the green energy generators is the Solar Power Plant (PLTS), one of the green energies developed by the Indonesian government to replace energy derived from fossil fuels (Parti et al., 2023).

Educational strategy

In delivering alternative energy concepts, various educational strategies can be used. The selection of suitable learning models, learning approaches, or learning strategies affects student learning outcomes and classroom processes (Pathoni et al., 2021). Students today are no longer satisfied with learning knowledge from paper books, they prefer having interactive elements when they learn the knowledge, such as learning by using technologies involving multimedia (Yau et al., 2020). Teaching and learning approaches that include the ideas of sustainable development allow the attention of young people to be extended beyond the classroom into the real world and engage them in the process of devising solutions to social and environmental problems they face as citizens (O'Neil et al., 2020). Students' critical thinking skills fall into the category of being less proficient. This is due to students' lack of literacy regarding renewable energy and their unfamiliarity with working on questions with high-level thinking skills. Another cause is that physics learning is less varied and experiments are rarely carried out (Yuliarti et al., 2023).

Therefore, to analyze the trends in the teaching and learning strategy of alternative energy, the author categorized the educational strategy used among the 15 articles. There are six types of educational strategies used in these 15 articles, which are neuroscience

(pedagogical), project-based learning, STEM learning, professional development, problem-based learning, and virtual lab.

Ott et al. (2018) pose that the introduction of alternative energy education, to a certain extent, could gain by regarding a discussion of problems with resistance emanating from aspects such as revolution, evolution, enrichment, or provocation of established educational approaches for teaching and learning about traditional energy conversion processes. introduction of renewable energy education, to a certain extent, could gain by regarding a discussion of problems with resistance emanating from aspects such as revolution, evolution, enrichment, or provocation of established educational approaches for teaching and learning about traditional energy conversion processes.

Among the 15 articles, 3 articles used project-based learning as the educational strategy to teach alternative energy. Simson et al., (2022) integrate two project assignments to teach alternative energy. The first project was to investigate an energy generation facility in the context of the geography, impacted communities, and current energy infrastructure in the area. Meanwhile, the second project asked students to choose two particular products or process alternatives and investigate their different inputs, wastes, emissions, and social impacts. Through these projects, the students showed overwhelmingly positive responses. They enjoyed the diverse cohort, set of topics, focus on group work, and the projects. Chen & Lin, (2021) implemented project-based learning by asking the students to design various types of solar power and wind power devices. In this study, we applied PjBL to address the interdisciplinary issue of sustainable energy, emphasizing the engineering technical skills involved. The learning process was carried out through five stages, which are preparation, implementation, presentation, competition, and feedback. Benitz & Yang, (2021) built a course that consisted of five lessons mainly discussing wind turbines. Leeson 1 focuses on energy and energy transfers, to prepare the fourth graders to think about these concepts as they relate to wind turbines. Lesson 2 introduces wind, how it is generated, and a discussion of its resources. Lesson 3 focuses on the engineering design process with a brief introduction to wind turbines and their components. Lessons 4 and 5 were spent designing, building, and testing windmills and wind turbines, guided by the engineering design process. Mechanical energy is the focus of Lesson 4, where students measure the weight lifted by their windmills. In Lesson 5, students begin to explore electrical energy using multimeters and/or LEDs.

Zuvur et al. (2020) stated that the use of alternative energy sources as a teaching tool in the classroom helps to acquaint students with a deeper, more scientific knowledge of science, to prepare them to solve life problems. Without practical work, elaborating to others or debating on abstract concepts heavily relies on textbooks and they could only be achieved within students' imagination. However, the situation is reversed once discussions interact with practical work (Fung, 2020). Another educational strategy used to teach alternative energy is STEM Learning. Articles by Egbue et al. (2015) and Wagner et al. (2017) integrate STEM learning into their educational strategy. Egbue et al. (2015) conducted a STEM workshop that consisted of two 50-in sessions of approximately 15 students each. Each session consisted of two parts. The first part, which was 30 min long, took place in a classroom and included the pretest questionnaire, a presentation, and a discussion. The second part took place in a laboratory and involved a demonstration of electric vehicle operation and the post-test questionnaire. Presenters of the workshops included four graduate students and a postdoctoral fellow in three engineering disciplines: engineering management, electrical engineering, and mechanical engineering. The result of the workshop shows that Early exposure to Meaningful engineering experiences for these young girls may boost interest and the eventual pursuit of engineering and technology education paths. Students had a clearer understanding of the engineering profession and a strong understanding of the basic concepts of electric vehicles. They also understood the geographic implications of the technology, particularly those materials (in this case lithium) that are sourced from various parts of the world. The participants seemed more confident in their responses to questions about electric vehicles and most were able to correctly name three or more countries that had lithium reserves and resources.

STEM subjects are a particular case of the application of education for sustainable development (ESD). This aims to increase student awareness about the linkages between their subject and sustainable development; the potential impact and contribution their activities can make to its achievement; and the development of competencies that they can carry forward in their careers where they have the potential to make significant differences to people and the planet (Hopkinson & James, 2010). Nazhifah et al. (2023) found that STEM-based renewable energy e-learning to improve the creative thinking skills of high school students has been feasible and acceptable to students. This is supported by Sudrajat et al. (2023) who found that EDP-based learning can increase students' creativity, both their creative thinking skills and their creative products.

Wagner et al. (2017) present a hands-on laboratory activity developed for an introductory environmental science course that uses tabletop wind turbines designed

to improve students' STEM and energy literacy and to introduce them to the science and technology of wind energy and basic land use considerations of siting wind farms. In this lab, students conceptualize and calculate the basic physical properties of wind energy potential and production by measuring velocities and calculating optimal energy production through various modifications to turbine placement and blade manipulation. Students construct mini-wind farms with multiple turbines and manipulate the footprint and height to achieve the greatest energy production on the smallest footprint thus incorporating land use considerations. This lab engages students, most of whom are not STEM majors; supports their ability to solve a real, hands-on integrated STEM problem; and increases their understanding and ability to communicate about the scientific and technical aspects of energy, in particular wind energy. A study by Rabbani et al. (2023) revealed that most teachers and students have not used worksheets with activities to boost their Creative Problem-Solving skills. Therefore, developing a learning program on PjBL-STEM integrated renewable energy is necessary.

The other educational strategy used to teach alternative energy includes a professional development program, problem-based learning, and virtual lab activity. Professional development was used by Merritt et al., (2019) to explore students' energy literacy development in fourth-grade classrooms. developed a curriculum on energy resources aligned with the Next Generation Science Standards. We then trained teachers on how to implement the program and develop a service-learning project related to energy conservation with their students. Qualitative methods were used to analyze students' open-ended responses from an energy literacy assessment. Students were familiar with solar, hydropower, and wind energy, and suggested that solar energy should be used more in the future. Students were more easily able to explain energy transfer in wind turbines and solar panels than in other electricity production systems. Students learned important energy and natural resource concepts in the context of a service-learning program. The discussion focuses on the importance of integrated science instruction that helps students see how their electricity use impacts the environment and provides them with opportunities to act. This is in line with Morris et al. (2021) who found that Students highly valued the practical and hands-on nature of the program in comparison to their typical classroom experiences, and strategy of providing students with concrete experiences. Providing an appropriate amount of teaching modules can help the teacher to conduct the learning process. It is necessary to develop digital teaching materials based on the CPS model integrated with renewable energy to form energy-saving characteristics in students (Widya et al., 2023). E-Module can be a means to assist and facilitate teaching and learning activities so that effective interactions will be formed between students and teachers so that they can increase student activities in increasing learning outcomes. The created e-module integrates the problem-based learning model. The problem-based learning model is a learning model that can improve students' 21st-century abilities (Nilyani & Ratnawulan, 2023).

Suyatman et al. (2021) revealed that analytical thinking skills in the concept of new and renewable energy in the experimental group that was taught by problem-based learning were higher than in the traditional contextual learning. Innovative learning like PBL had the potential as an alternative method to increase the analytical thinking skills of students. This is in line with Owens & Hite (2020) who found that the results of teacher perception data and researcher observation suggested the global PBL developed students' abilities to share and understand ideas, use multiple representations to present those ideas and be more receptive to perspectives different than their own.

Pastor et al., (2020) focus on the incorporation of remote/virtual laboratories, showing how these labs were developed/integrated into online courses. To validate the incorporation of this type of resources in an environment usually not online, a set of surveys was designed to support a technology evaluation methodology (TAM, Technology Acceptance Model). This evaluation allows knowing the degree of satisfaction with the technology (remote and virtual laboratories as resources) using a structured experimental method (SEM, Structural Equation Models). As a result of the application of this experimental method, the calculated statistical data indicate that the use of remote and virtual laboratories improves the perception and use of virtual environments at a distance. Also, it can be indicated that these laboratories are presented as an essential resource to improve the quality of online teaching in engineering courses. Zhu & Wang (2020) highlighted that an intelligent and adaptive learning platform coupled with well-designed team-based activities can indeed increase students' engagement in learning in a wide variety of activities and contexts, from personalized learning to team collaboration, including classroom participation and asynchronous postings on a discussion forum. Truchly et al. (2018) support the statement by finding that students were motivated to study because new technologies were included.

Other than that, Revák et al. (2019) suggest that curricula and textbooks could have a significant role in solving alternative energy learning strategy problems if they do not focus on terminology-level knowledge but

take some attitude and approach forming elements among the requirements. The incorporation of as many tasks of observation, experiment, data analysis, cooperation, and project work in textbooks and workbooks as possible could also help to familiarize the concept of alternative energy to the student. This is supported by Zuvur et al. (2020) who highlighted that it is important to familiarize students with information on alternative energy sources, to develop a scientific and methodological framework for the creation of a system of using alternative energy sources as a learning tool, to use natural energy sources in students. This is in line with Kelley et al. (2020) who found that the science teachers' self-efficacy increased after professional development and after the lesson implementation.

Conclusion

This study addressed the analysis of the current trends of alternative energy education in the school setting in terms of educational level scope, content area, and educational strategy. PRISMA method which includes identification, screening, and inclusion phase was used. The data was gained from the Scopus database with the search string TITLE-ABS-KEY (("Alternative Energy")AND("Education")). After the identification and screening phase, 15 articles were brought to the inclusion phase to be read and analyzed. The result highlighted that the educational level covered in alternative energy education mainly focused on secondary and university levels. It is found that at elementary and high school levels, there are insufficient amounts of alternative energy education happened. The second analysis relies on the coverage of the content area of alternative energy topics. Most of the papers covered general alternative energy as the topic. Meanwhile, the rest of the articles mainly focus on one type of alternative energy as the topic. Educational strategy analysis among the articles brought to the conclusion that project-based learning was the most common learning strategy in teaching alternative energy. STEM learning comes as the second common learning strategy. Pedagogical, professional development, problem-based learning, and virtual lab were also utilized to teach alternative energy. The limitation of this research lies in the narrow scope of the data that only compiles data from the Scopus database. For further research, it is suggested to implement alternative energy education widely to help the achievement of Sustainable Development Goals.

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The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results

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