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Early Childhood Interpretation of the New Jersey Offshore Wind Program

RESEARCH AND EVALUATION

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ABSTRACT

As our climate warms and fossil fuel resources deplete, offshore wind projects seek to provide much-needed renewable energy. However, these projects are often faced with criticism from the communities within which they are situated. The accuracy of these criticisms varies significantly: some are fueled by legitimate concern, while others have been scientifically discredited. Individuals' energy literacy, or their ability to understand energy-related topics, can shape community members' perspectives on offshore wind and susceptibility to misconceptions. Energy literacy is dependent on knowledge of scientific content, which begins in the early elementary school years. This study explores the energy literacy of 10 young children living in the community adjacent to a forthcoming offshore wind project in coastal New Jersey. The study utilizes a "draw and tell" drawing-based methodology, commonly used for its credibility and reliability with young participants, to describe their perspectives. We found that while the children's energy literacy was generally low and included many misconceptions, their explanations for energy were grounded in observation, personal experience, and past learning at school. These findings shed light on future efforts to teach about energy literacy in early grades to foster a well-informed populace.

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INTRODUCTION

The Jersey Shore saw an influx of protestors both resistant to and in favor of offshore wind energy opportunities in the past decade. The New Jersey Offshore Wind Program (NJ Offshore Wind Program) became a widely debated issue in the Jersey Shore community (New Jersey Board of Public Utilities, n.d.). Rallies, protests, lawn signs, news reports (Goldner 2023; Phillips 2021; Phillips 2025), and heated discussions between adults demonstrated the magnitude of the controversy. Community members of all ages throughout the New Jersey Shore region have expressed concerns about the offshore wind farms; yet the information used to support claims varies with respect to scientific accuracy, suggesting that energy literacy, or one's ability to comprehend energy-related topics, is not universal among the occupants of the New Jersey Shore of all ages (Goldner 2023). Offshore wind development represents a growing intersection between marine environments and human energy systems, making it an important topic within marine and environmental education. Children hear the adults' conversations about this contentious topic; thus it is critical to better understand how their conceptions and perceptions develop amidst the controversy. From a social constructivist perspective, knowledge is formed through a combination of interactions with others and self-reflection (Vygotsky 1978). It is therefore critical to better understand the way in which children build understanding about this topic, which may or may not have been introduced at school, through observation of adults' conversations, or other media sources such as television news.

Not surprisingly, research demonstrates that among children, many students, even in upper elementary school, lack energy literacy (Merritt et al. 2024). In order to understand wind turbines and the ways in which offshore wind farms provide renewable energy for communities, one has to be familiar with these topics. However, Merritt et al. (2019) research found that "most elementary students did not know how fossil fuels are extracted or where they are found; believed that natural gas is the same thing as gasoline; that oil does not cause many problems in the world other than oil spills; and that fossil fuels can form in a short time" (p. 1079) despite formal education in climate change-related topics. Later studies revealed mixed levels of energy literacy across topics, which could increase with purposeful instruction in the elementary years (Merritt et al. 2024). In a study of 6-12-year-old children in Belgium, Pearce et al. (2020) found that children have strong self-efficacy in their own energy curtailment behavior (e.g., not wasting energy), suggesting that energy literacy is nuanced. While children may have an understanding of the value of not wasting energy, they may not understand how conserving energy resources is connected to other elements of energy literacy, such as renewable versus nonrenewable sources.

While many researchers agree that energy literacy is an important topic for young people to be proficient in (Merritt et al. 2019), not much research has been done on when schools should start teaching this content. There is also a gap in the knowledge base about how younger students — specifically in early childhood education — perceive and conceptualize energy. Since energy plays such a large role in our climate crisis, it permeates our culture. In a recent study, Ortega-Quevedo et al. (2024) were able to create a scale for climate change competence for preteens (aged 10–12). This scale was useful for measuring content related to energy literacy, such as causes of climate change and mitigation strategies, suggesting that children as young as 10 might be ready to learn about the topic. Similarly, Hu (2026) found that children in kindergarten (ages 4 and 5) were able to describe energy conservation as a climate change mitigation strategy. These findings suggest that it is possible to begin to introduce ideas around energy literacy at the early childhood stage of development.

Students are inevitably going to hear opinions from their families and the media about energy, but do not yet have the analytical skills and content knowledge to form their own opinions (Çoker et al. 2010). Pearce et al. (2020) found that parents and teachers had the biggest influence on children's energy curtailment. Similarly, Léger-Goodes et al. (2023) found that parents' opinions were critical in shaping 8-12-year-old children's understanding of climate change, including mitigation strategies such as energy conservation. This raises concern because students will likely inherit the opinion they most commonly hear in polarized discussions among adults without critical analysis based on facts. Since many older students hold misconceptions about energy as well, this flawed understanding is likely passed down to the younger generations without early intervention. Posner et al. (1982) introduced the idea of conceptual change

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theory, which asserts that in order to replace incomplete understandings and misconceptions with scientifically accepted explanations, children need opportunities to see their earlier conceptions fail before changing conceptions. This suggests that energy education should be nuanced and purposeful, taking into account the variety of prior knowledge children bring about this topic before introducing new ideas.

New Jersey is one of the leading states in environmental education. In 2020, New Jersey became the first state to require climate change education in state standards across all subjects. However, these standards do not include energy instruction until the fourth grade (New Jersey Department of Education, n.d.). In total, teachers only need to meet ten standards related to energy instruction throughout K-12 education (New Jersey Department of Education, n.d.). Therefore, it is important to note that teachers struggle to maintain the many standards they must address throughout the school year in order to meet standardized testing goals. Knowing that New Jersey is a leading state in climate change instruction, it is important to consider that teachers in other states may be required to meet even fewer energy-related standards. This article does not condemn teachers for not being more direct in energy instruction; rather, it acts as a recommendation for policymakers to focus more on addressing energy literacy. New Jersey schools use Next Generation Science Standards (NGSS Lead States 2013) as their science learning standards. As a result, students are not formally taught the science content or skills to fully engage with energy topics (e.g., types of energy, energy transfer, and climate impacts) until at least fourth grade in New Jersey. By this point, students are sure to have been exposed to adults' views about energy concepts. These views are often misconstrued and then become absorbed by the students as their own from birth to about age ten. The NGSS standards are broken up into several broad disciplinary categories, then further compartmentalized into subcategories in each grade. Renewable and nonrenewable energy are mentioned as mere subcategories of the "Earth and Human Activity" standards. Per the lack of formal instruction within the topic of energy, Merritt et al. (2019) found that "Students of all ages have difficulty distinguishing between renewable and nonrenewable energy resources" (p. 1080). This suggests that the minimal energy-related instruction in the early elementary grades is insufficient for building energy proficiency in students.

Students should receive information about energy in relation to the climate crisis to make informed decisions as early as possible. However, even in schools that directly approach climate topics, educational approaches remain ineffective (Merritt et al. 2019). Merritt et al. suggest one reason for this is, "Traditional instruction [in schools] on these topics may provide information, but rarely excites students to use their knowledge to produce change" (p. 1078).

The issues we are beginning to notice due to climate change will eventually become problems that future generations must manage. Merritt et al. (2019) conclude that "If students start learning these concepts early, they will be ready to make important decisions needed for our society in the future" (p. 1078). To equip students to make informed decisions later in life, as educators, we must prepare them with the necessary conceptual knowledge. Preparing students with the necessary content also allows them to engage with the topics in a more meaningful way and join in the seemingly "adult" conversations that will have effects on them later in life.

The evident lack of energy literacy is particularly relevant when considering community responses to renewable energy projects, including debates surrounding wind turbines. That being said, it is possible that advocates on both sides have varying levels of energy literacy. This is evident by the fact that many citizens were unaware of what wind turbines would look like from far away, whether the cost would be a net positive or negative for the community in terms of saving money on fossil fuels, and misconceptions about how wind turbines impact the environment.

NEW JERSEY OFFSHORE WIND PROGRAM

The NJ Offshore Wind Program has been under development since 2004 (New Jersey Board of Public Utilities, n.d.), but it did not become widely visible to the public until 2023, when new legislation supporting offshore wind investment was passed. CBS News reported that in July of 2023, Gov. Phil Murphy passed a law "that will provide millions of dollars in tax credits and private investment to the offshore wind industry" (Goldner 2023). At this point, media outlets

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picked up the topic, and it became controversial in shore towns. The public began to rally, protest, and put up lawn signs, reflecting community polarization. Today, the state remains committed to offshore wind development, although the program remains subject to political shifts and public debate.

The controversy surrounding the Offshore Wind Program stems from a combination of environmental, economic, and social concerns that could significantly affect New Jersey residents. One of the biggest concerns about wind turbines is their effect on marine life. While surveying the area in 2023, NJ recorded seven humpback whale strandings, the most in seven years (Goldner 2023). However, there is no scientific evidence to support the correlation between marine animal deaths and wind turbines (NOAA 2024). Residents are also concerned about the potential harm to various species of birds. This is a more legitimate concern, as the U.S. Department of Energy has stated, "Birds sometimes collide with wind turbine blades, and wind farms have the potential to disrupt bird habitats." However, the government is taking major steps to avoid as much disruption as possible by using anti-perching devices and flashing red lights to deter birds (U.S. Department of Energy, n.d.). Another concern is that offshore wind infrastructure requires substantial initial investment, creating an immediate financial strain. Wind turbines would also be visible from the beach, and many worry that this could deter tourists (Goldner 2023). Many Jersey Shore communities rely heavily on summer tourism, leading some residents to worry that visible turbines could harm local economies. These concerns impact the implementation and construction of the wind turbines.

While there are some drawbacks, the NJ Offshore Wind Program also promises many positive effects. Some of these include reducing carbon emissions, creating jobs, and providing financial benefits from the low cost of wind energy. Since wind energy is renewable, it would significantly lower New Jersey's carbon footprint by replacing fossil fuels with renewable energy (New Jersey Offshore Wind, n.d.). The New Jersey government states that the project has the potential to inject about $1.9 billion into the state's economy (New Jersey Offshore Wind, n.d.). The goals of the offshore wind program are to generate 11 gigawatts of clean energy, which could power over three million homes by 2040, and to reduce greenhouse gas emissions by 80% by 2050 (New Jersey Offshore Wind, n.d.). Additionally, the company Atlantic Shores promises to create 50,000 job opportunities in New Jersey. For many residents, these projected benefits are enticing. Both the pros and the cons significantly affect the everyday citizens of New Jersey.

The complex nature of the debate around New Jersey's offshore wind program underscores the importance of education to support energy literacy. Approaching energy instruction requires a broad understanding of the various topics within the discipline. Merritt et al. (2019) state that "Energy literacy is multi-disciplinary, includes cognitive, affective, and behavioral components, and encompasses a variety of skills and concepts" (p. 1079). The NJ Offshore Wind Program involves concepts such as renewable energy, economic risks and benefits, as well as geographical implications. To participate meaningfully in discussions about offshore wind development, individuals must understand the interdisciplinary concepts that shape energy systems.

In relation to the NJ Offshore Wind Program, early childhood students likely have little background knowledge to use in context. Students have likely little prior knowledge on what wind turbines are or how they operate in an educational context. Therefore, as students encounter protests, news reports, and conversations among adults, they may begin to form their own ideas about offshore wind turbines. However, without a formal background understanding, the worry becomes what knowledge students are actually constructing and how accurate it is. According to Vygotsky's (1978) theories, knowledge is socially constructed. Students who encounter discussions in the media or conversations within their communities may construct their own understandings of the NJ Offshore Wind Program without formal instruction. Since students are exposed to these discussions outside of school, they may begin constructing their own interpretations of energy long before formal instruction occurs. However, there is no current research on how early childhood students respond to seemingly controversial environmental energy programs. Therefore, the purpose of this study is to investigate how early childhood students understand offshore wind turbines and their role in energy production. This study aims to identify common misconceptions about offshore wind turbines and energy production among young learners. Understanding how young learners make sense of the NJ Offshore

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Wind Program through Girl Scout programming may inform energy literacy curriculum and instruction in the early grades. Furthermore, the research question that is driving this study is: How do first-grade students living in a coastal community conceptualize offshore wind turbines and their environmental impacts?

LITERATURE REVIEW

Since climate change is such a prevalent and heavily debated topic, it is imperative that evidence-based research regarding the environment is taught in schools to avoid a further spread of misinformation. Reducing greenhouse gas emissions and protecting our ecosystems will become the responsibility of students today, since they are the hope of our future. Therefore, students must begin understanding the controversies, myths, and truths about climate change early in their education to be environmentally conscious adults who can advocate for our environment with research-based opinions. One important aspect of being environmentally conscious is having a sense of energy literacy, or understanding types of energy, energy transfer, and climate impacts. It is especially important to instill energy concepts in young children because it is reported to affect a student's energy usage within a home and their energy-related habits more generally (Craig & Allen 2015). Furthermore, our students must be informed about energy and environmental discussions within the community. Otherwise, students may be easily swayed by myths and hold false beliefs about renewable energy. Thus, this study aims to understand how first-grade students at the Jersey Shore comprehend energy transfer concerning the NJ Offshore Wind Program.

Three intersecting areas comprise the grounding for this study: The first is energy literacy, its definition, importance, and the minimal presence it has among students. This section describes to the reader why energy literacy is relevant and how our education system falls short in its ability to support energy literacy. Next, the value of teaching energy literacy to young children in early childhood education specifically. Most research regarding energy literacy falls into secondary education or adulthood; however, various sources discuss the relevance of these topics within younger grades. Finally, we discuss implications for pedagogy and curriculum. The implications from prior research suggest changes either in praxis or curriculum to better contextualize the present studies' implications.

ENERGY LITERACY

As global warming becomes increasingly evident each day, it becomes essential that the next generation becomes environmentally conscious. Many researchers agree that students should be taught energy-related topics explicitly in school (Çoker et al. 2010). The most effective way to decrease carbon emissions is to avoid burning fossil fuels. However, society still needs to power homes and businesses. Therefore, an alternative energy source is required to lower emissions and protect the environment while still providing essential resources in a capitalist society. This is where the need for energy literacy comes into play. Energy literacy refers to one's comprehension of energy-related concepts (Merritt et al. 2019). Energy-literate adults are better equipped to make effective decisions concerning energy usage and environmental policy, making energy literacy a vital skill. Unfortunately, children and adolescents are underdeveloped in such topics (Çoker et al. 2010). Otto et al. (2019) conducted a study following students' environmental attitudes and behaviors starting at age seven through adolescence. Environmental attitude refers to one's perceptions and opinions toward the environment, while environmental behavior refers to active participation in actions that perpetuate the global climate crisis or combat it. Otto found that environmental attitudes and behaviors, scaffolded by an adult, increase until age 10. They then stagnate and decline around ages 14 to 18 (Otto et al. 2019). This study informs the current research that early childhood, up until age 10, is the best time to scaffold an understanding of energy-related topics, as students will be most susceptible to incorporating related attitudes and behaviors in their personal lives. Yet, Castañeda-Garza & Valero-Urena (2022) found that energy-related information is few and far between in science textbooks. This is especially concerning because when students are not explicitly taught these topics, they form misconceptions that are rarely corrected in adult life (Rule 2005). These misconceptions in childhood create energy-illiterate adults, resulting in policymakers who are unable to make informed decisions about energy and the environment.

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Boylan (2008) surveyed 132 elementary students who had participated in a regional energy program about climate change and renewable and non-renewable sources of energy. The research concludes that while elementary students can name types of energy, they show considerable confusion about the differences between renewable and non-renewable energy (Boylan 2008). Research suggests that students are aware of terminology but lack conceptual understanding of energy-related concepts.

EARLY CHILDHOOD EDUCATION

Young children are an especially interesting demographic because so few are explicitly taught about energy. Castañeda-Garza and Valero-Urena (2022) took a systematic approach to identifying common themes across 44 different science textbooks commonly used in the region. He found that in Mexico, before third grade, the average textbook had only 18 pages of energy-related content, while the upper grades had 112 (Castañeda-Garza & Valero-Urena 2022). Additionally, Merritt et al. (2019) conducted a qualitative analysis connecting themes of 101 students' grades 4–6 end-of-unit assessments after participation in an energy-centered Connect Science unit. He found that only 37% of students could accurately describe energy transfer, even after this explicit instruction. However, there is no evidence to support that students are incapable of understanding an abstract concept such as energy transfer. On the contrary, young students have proven especially capable of doing so. One study focused on participants in kindergarten through third grade and found that with explicit instruction, not only did students' memorization of energy-related content increase, but students also became more energy-conscious by changing their behavior related to energy (Craig & Allen 2015). Meaning, students used less energy themselves and even convinced their families to limit energy usage by learning and understanding the content through explicit instruction. These findings suggest that not only are young children ready for this content developmentally, but they can also play a pivotal role in educating adults. Research also concludes that younger students are more susceptible to learning environmental concepts in contexts outside of formal schooling. In a study involving Girl Scouts aged 9-14, Junior Girl Scouts deepened their understanding of climate change and energy conservation more than the Cadettes, who are the older population, after every environmentally conscious patch (Puttick et al. 2015). Evidently, young students are competent in abstract reasoning enough to learn energy concepts, even more so than their older peers. Since many misconceptions about energy are formed in younger grades, some researchers even propose that it is better to begin teaching energy early on to avoid confusion (Rule 2005).

CURRICULUM SUGGESTIONS

Researchers studying students' energy literacy suggest that curriculum changes are necessary to highlight the importance of environmental topics. After an investigation of primary and secondary students' knowledge about renewable energy sources via open-ended questions, Çoker et al. (2010) recommend "Much more learning outcomes related to renewable energy sources must be added to the primary and secondary education curricula with environmental issues, which could be faced in daily life context" (p. 1491). It is important to note that this study was conducted in Turkey, and its application to the U.S. is limited due to differences in educational policy and understanding of the environment. The present study aims to explore the daily-life understanding of energy within geographical and political contexts. Since every community gets its energy from different sources, it is important that all citizens, including children, are aware of the benefits and drawbacks of the common energy sources used near them. Merritt et al. (2019) recommends scaffolding these concepts using models and diagrams to explain the process rather than the objects involved. This is especially relevant concerning wind turbines because it is one of the most visible sources of renewable energy compared to solar power and other more common energy sources. It is important, however, that this content is taught through a pro-environmental lens (Otto et al. 2019), especially if we expect education to result in action. Puttick et al. (2015) conducted a study that assessed a deepening of understanding in energy after participating in the Girls Energy Conservation Corps (GECCo) of Girl Scouts aged 9-14 from 65 troops. Puttick et al. (2015) research shows that hands-on activities correlate with motivation. In line with previous research, Craig and Allen (2015) found that energy-saving ideas learned in the classroom correlate with habits at

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home, underscoring the importance of encouraging students to pursue energy-saving habits within the curriculum. Extending these recommendations to the present context, an effective teacher could have students create models and diagrams that represent energy transfer to help students not only comprehend the process but also promote self-efficacy related to the ability to effect change. Many researchers also advocate for a change in textbook content. Particularly, Castañeda-Garza and Valero-Urena (2022) recommends introducing students to debates about renewable energy, such as the Offshore Wind Project, and how geographical location can be more convenient for different sources of energy.

These stated themes suggest that young students are lacking energy literacy and are capable of understanding abstract concepts such as energy transfer, resulting in the need for pedagogy and curriculum to reflect this. By looking at all these themes, this literature review contributes to an understanding of students' perceptions of energy, namely renewable energy. However, a gap exists in the research on student interpretation and perception of local energy disputes, particularly at the younger grades. Local disputes not only add interest, but they also open the possibility for exploration and discussion. They situate the learning of environmental science concepts into something concrete and meaningful rather than abstract and unengaging. This research will address this gap by focusing on subjects within a community that has struggled with differing opinions on local energy initiatives for years.

METHODOLOGY

This study seeks to answer the research question: *How do first-grade students living in a coastal community conceptualize offshore wind turbines and their environmental impacts?*

ANALYTICAL LENS

This research can be described as applied qualitative teacher research. This study is focused on observing students in an educational setting (Girl Scout programming) and is geared toward optimizing environmental pedagogy. According to Merriam (2009), applied research refers to research in which the goal is "to improve the quality of practice of a particular discipline" (p. 3). The goal of this research is to ultimately be used by policymakers and teachers alike to improve the quality of environmental education regarding renewable energy in a community-centered manner. Qualitative research is a category of research that seeks to make meaning of the world through descriptions (Merriam 2009). This research does just this, as it will first define how students make sense of wind turbines, then situate the positionality of educators in how to best support energy literacy in students with similar contexts.

SAMPLE/SETTING

One troop of fifteen first-grade Girl Scouts located in Ocean County, NJ, was invited to participate in this study. Ten of the fifteen were present and willing to participate on the day of the study. The participants were all first-grade females between the ages of 6 and 7. The participants were chosen on the basis of convenience sampling. The sample was also chosen due to the convenience factor that, geographically, the students were located near the beach and would thus have a higher chance of being exposed to the NJ Offshore Wind Project debate. The sample size is relatively small due to logistical constraints, but still provides reliable discussion points for qualitative research.

RESEARCH ETHICS

This study was approved by The College of New Jersey's Institutional Review Board (IRB). Parents of the Girl Scouts provided signed consent letters. Participating children provided verbal assent. An alternative activity, coloring sheets, was provided for any students uninterested in participating in the research for any reason. The research took place over two days. On the first day, Reynolds hosted a brief virtual orientation session (via Zoom) with the troop, where she explained the research goals to the students. On the next visit, Reynolds met in person with the troop and the troop leader to collect the data.

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DATA COLLECTION METHODS

This research uses triangulation, or multiple forms of data, to enrich its validity and credibility. This study uses participant drawings, written captions, and surveys to triangulate the data as well as to provide a rich and detailed description of events and context. This method is widely used in early childhood teacher research and known as the "Draw and Tell method" (Shin 2022). This refers to the collection of illustrations in conjunction with written explanations. In this study, Reynolds asked participants to first draw a picture of how wind turbines affect the environment, then explain their drawing through prose or orally with an adult who can transcribe their words. Transcriptions required an adult to write the exact words of the participant on their survey, then reread the text and ask the participant if it accurately reflected their thoughts. The drawings tell us what the participants know about wind turbines without the stress and pressure of traditional testing. Then, in the written portion, participants are able to explain their drawings. This helps not only avoid misinterpretation on the researcher's end, but also gives a chance to the participants to elaborate on the concepts touched upon in their drawings (Shin 2022). The final part of the data collection is an open-ended affective survey. Three questions were asked orally and were typed on a worksheet for participants to read along in the following order:

1. What is one reason that people may not like wind turbines?
2. What is one reason people may be in favor of wind turbines?
3. What kind of feelings do you have about wind turbines?

These questions, in their open-ended nature, allow for rich and thoughtful answers. However, students interpreted the questions in their own ways. When some students made comments about their answers, others would join and say the same. It is hard to tell if participants had similar opinions due to a vocalization of answers or if they were truly how each felt.

DATA ANALYSIS

This study analyzes the data collected by coding themes across the various types of data. Since all of the drawings and written answers are on paper, the data was first transcribed and downloaded onto a single spreadsheet to be interpreted with ease. After the data was transcribed digitally, themes that suggested energy literacy and misconceptions within the "Draw and Tell" dataset were identified and coded using a deductive qualitative approach (Saldaña 2013). The codes are related to the themes discussed in the literature review. Across the group of drawings, a few key items signifying themes were identified: accurate portrayal of wind turbines, the environment around wind turbines, and any inaccurate representations of wind turbines. Every data point was assigned one or more of these codes. Since the second part of the "Draw and Tell" method is simply an explanation of the illustration, it needed no further coding. However, it was important to use the verbal descriptions alongside the illustrations themselves to understand and analyze the picture from the participants' full perspectives.

Since the survey was focused on participants' drawings and verbal descriptions, the codes assigned were as follows: inaccurate understanding of wind turbines, wind turbines as beneficial to society, and wind turbines as eco-friendly. This coding scheme helped determine whether students were energy literate, along with how they perceive wind turbines in general. The analysis process was completed twice in an attempt to reduce bias without a second coder.

RESULTS

Through coding the initial survey, several themes emerged among the reasons students believed people to be in favor of or against wind turbines. Each student's answer is demonstrated in Table 1 below. The most prevalently stated pros and cons of the wind turbines included temperature, aesthetics, and wind. On nine separate occasions, students mentioned that wind turbines can change the temperature of the surrounding area. While most students stated that the breeze would be beneficial, one student noted that it could be too cold, and another stated that the breeze could be too much. Aesthetics was mentioned as a perceived downfall of wind turbines five times. Students reported that the large size could potentially be a factor in the reason they are widely controversial, one student noting that it blocks the view of the ocean. Additionally, one student was worried that the turbines would cause too much noise. Lastly, one student stated that the fans could create issues in that they would blow items away.

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STUDENT	WHAT IS ONE REASON THAT PEOPLE MAY NOT LIKE WIND TURBINES?	WHAT IS ONE REASON PEOPLE MAY BE IN FAVOR OF WIND TURBINES?	WHAT KIND OF FEELINGS DO YOU HAVE ABOUT WIND TURBINES?
1	Loud	Windy	Too big
2	I think people like it	On hot days it brings a breeze	I think they are cool
3	Some things could blow away	Because they give people fresh air	They look nice and give me air
4	It is cold	Not sure	They look pretty
5	I don't know what it is	I don't know	They are pretty
6	Because it is large	Because it is refreshing	I like them
7	I not sure	–	–
8	They might not like it because you can't see the ocean	They might like it because they might be hot so that will have a breeze	They look ugly and I hate it
9	I don't know?	They make air	I never seen one before
10	It might make too much air/too windy	Not sure	They are ugly

Table 1 Survey Responses.

Note: These are the participants' verbatim responses to the pre-activity quiz.

The explanations of students' drawings included both accurate descriptions of wind turbines and misconceptions. The common themes included the confusion of windmills with wind turbines, wind turbines being located near bodies of water, students interpreting wind turbines as having fan-like tendencies, and untrue or irrelevant statements in students' responses. Representative responses are shown in Table 2. Two students drew what they described as windmills, using the term interchangeably with wind turbines (Figures 1 and 2). Next, four students noted that their turbines were near or in a body of water, such as a beach, as in the images of student 8 and student 9. Four students also described their turbines as having fan-like tendencies, such as producing cold air and spinning. Lastly, eight of the ten students described wind turbines inaccurately or omitted relevant information entirely.

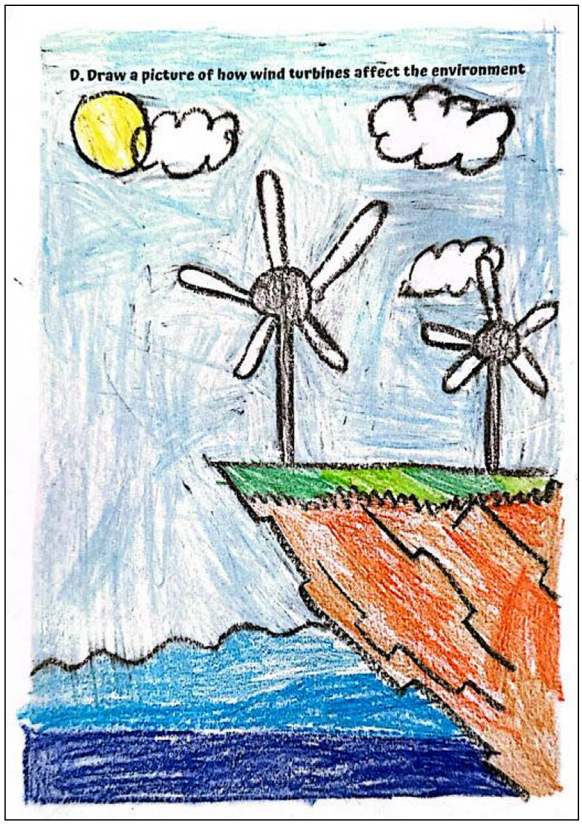

Figure 1 Student 8.

Note: Student 8 described this image as, "My drawing is a cliff with water under it and a fan on top." This image focuses on her own interpretation of the wind turbine (a "fan") and an image of the shoreline as a cliff.

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STUDENT	EXPLAIN YOUR DRAWING
1	I drew a flower.
2	It is near the beach. It is spinning. Some can be black.
3	My drawing explains how wind turbines give cold air.
4	My drawing is with a windmill and a house.
5	They look like windmills. They are in China.
6	Wind turbines at the beach.
7	Wind turbines.
8	My drawing is a cliff with water under it and a fan on top.
9	My wind turbine is with a cool dude sun with a background.
10	They are near the ocean. They are spinning.

Table 2 Students' Explanation of Drawings.

Note: Students each provided explanations of their drawings which were either written or transcribed verbatim by Reynolds.



Figure 2 Student 9.

Note: Student 9 described her image as, "My wind turbine is with a cool dude sun with a background."

DISCUSSION

This data demonstrates students' lack of energy literacy for a few reasons. First, students were largely unsure what a wind turbine is or its purpose despite living in an area where they are of major importance and political discussion. This was shown by many omitted answers or inaccurate interpretations of wind turbines. Many of the children's images were literal and descriptive accounts of what they could see with their eyes alone. Additionally, at least one child created images that combined information across sources, such as stereotypical imagery of suns as "happy" next to a wind turbine, suggesting that they were building conceptions using multiple knowledge sources (e.g., personal experiences at the beach, knowledge that the turbines would be built offshore, images from cartoons and other children's media). This

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response supports the notion that children construct their understanding using multiple perspectives and sources (Vygotsky 1978).

Students also produced multiple misconceptions about wind turbines, using multiple sources of knowledge. They conveyed that wind turbines are interchangeable with windmills, that they are just large fans, and that they can change the temperature on the shore, drawing on personal experience with fans and perhaps exposure to images of wind turbines absent an explanation of how they work. This finding supports Rule's (2005) study, which suggested that students form misconceptions when left unexposed to factual, concrete information about energy. Students appear to base their understanding of wind turbines on familiar objects with similar shapes, such as fans and windmills. In order to change conceptions, the children would need opportunities to observe and explore turbines more thoroughly (Posner et al. 1982). Interestingly, across the board, the children omitted any reference to the environmental impact of wind farms, such as disruption of bird migration patterns.

That being said, students may have picked up on some of the political opinions about wind turbines. Students were able to correctly draw wind turbines near or in water, which shows students recognize the NJ Offshore Wind Project. Students also correctly acknowledged two of the biggest worries citizens have about wind turbines: noise and aesthetics. At least one student reported that the turbines were "ugly," suggesting that she may have been exposed to adult or media discussion about the negative opinions held by adults about this topic. This data supports the understanding that students are never too young to begin conceptualizing scientific information rooted in real-life experiences (Otto et al. 2019). Within the community they live in, these students have likely seen discussion of this topic on the news, as lawn signs, and in various other ways. The conflict they've witnessed has made a lasting enough impact to allow them to describe complications wind farms could create.

These findings also suggest that even among a small group of 10 children, a variety of prior knowledge exists about wind turbines ranging from "I don't know" to fairly complex ideas about these tools acting as fans to cool the beach. This suggests that introducing energy education in classroom settings should begin with opportunities to confront incomplete knowledge and misconceptions. Later, teachers can provide children with observational experiential activities to develop a more accurate sense of how wind turbines work, before introducing actual controversy (e.g., effects on bird migration) and benefits (e.g., clean energy sources, possible economic implications).

CONCLUSION

These findings suggest that young students would benefit from stronger foundations in energy literacy. This study demonstrated that young students, though living in the heart of one of New Jersey's largest environmental controversies, lacked the awareness to describe a wind turbine accurately. Young students would likely benefit from direct instruction about the environmental issues taking place in their region. Yet, careful attention must be paid to the instructional design of energy literacy lessons. It is clear that within communities with a high potential to be affected by these large-scale projects, children have a wide variety of prior knowledge and ideas about the topic.

Energy literacy, especially as it serves as foundational knowledge for understanding solutions to the impacts of climate change, is a key component of climate literacy. As sea level rise continues to affect coastal communities around the globe, understanding the ways in which mitigation efforts, such as decreasing atmospheric carbon through the use of clean energy sources, can help all community members mitigate the impacts of our changing climate. Therefore, exposing learners to instruction on climate literacy can serve as a stepping stone for developing solution-oriented climate literacy.

Students can then begin to learn the intricacies of energy and start the road to energy literacy. Understanding the misconceptions and gaps in energy literacy among young learners may help educators and policymakers design curricula that support environmentally informed decision-making in coastal communities. As offshore renewable energy projects become increasingly common in coastal regions, helping young learners understand these technologies may play an important role in fostering scientifically informed communities. However, it is important to

note that this study contains limitations that would require further research to eliminate other interpretations. The small and localized sample is the most significant limitation in this study. Students in this study were all from the same county. If further research concludes that other shore towns have different interpretations of wind energy, the conclusions of this study may be void or altered. Having a small sample size of ten participants means that the results may be skewed for this particular group, and therefore it is difficult to draw concrete conclusions. Students who participated in this study were young, at 6–7 years of age. However, the wind energy controversy began in 2023, when these students were approximately only 3 years of age. It is possible that their age plays a role in not recalling the significance of these events.

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COMPETING INTERESTS

Lauren Madden a member of the editorial board for Current: The Journal of Marine Education, but had no involvement in any editorial processes related to the handling of this submission. All other authors have no competing interests.

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