Presenting a Wind Turbine Model for Climate Change Education and Action

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Abstract

This article presents and assessment a climate change education model - a wind turbine model.

This model has been developed based on extensive technical literature review, from which the essential aspects of climate change education have been extracted. The wind turbine model is a comprehensive educational tool for climate change, emphasizing the importance of the following aspects: knowledge, critical thinking skills, values awareness, identity, worldview, practical actions, motivation, participation, future orientation, hope, and other emotions, as well as operational barriers.

In this study, we have considered wind as one of the effects of climate change and a turbine as a means, not for production but for combating climate change. Each component of the turbine, such as the generator, gearbox, and transformer, is also considered as part of this system to enhance knowledge, environmental perspective, and behavior in the family.

Finally, this model is presented for environmental education through social networks in families. After presenting the above-mentioned action plan to combat climate change, they have been ranked. Finally, this article discusses how to develop this model in the future.

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I. Introduction

As climate change has become one of the world's biggest environmental challenges, countries have become increasingly aware of the importance of climate change education [1][2]. However, climate change is a wicked problem with no simple solutions [3]. For that same reason, climate change education can also be described as a wicked problem. Although climate change is strongly present in current politics, economics and pedagogy, studies have found climate change education often incomplete and narrow-minded [4].Traditionally, climate change is only dealt with in natural sciences, particularly biology and geography. However, to understand the implications of climate change and to promote climate-responsive action, it is also necessary to understand social sciences, health sciences and politics [5]. In addition, ethical and humanistic perspectives must be taken into account in climate change education, as the topic raises strong feelings such as guilt, hopelessness, helplessness and even anger [6][7]. Several studies have found that teachers' knowledge of climate change is deficient and fragmented, and that teachers have many misconceptions [8][9]. Furthermore, integrating multidisciplinary climate change education into schools is challenging, as many teachers continue to see climate change quite narrowly, mainly as an issue related to natural sciences [10][11][12].. Furthermore, integrating multidisciplinary climate change education into schools is challenging, as many teachers continue to see climate change quite narrowly, mainly as an issue related to natural sciences [12]

Environmental and sustainability education models were not designed specifically to address the complexity of climate change, which involves interconnected ecological, social, and economic factors. While these models provide a useful foundation, they do not fully capture the multifaceted nature of climate change education. To date, there is a lack of comprehensive models that can effectively address the range of issues related to climate change education in a holistic way.. Researchers such as Shepardson et al. (2012)[13] have modeled the important scientific aspects of climate change education, and a large amount of literature exists on what aspects should be considered in climate change education. The article aims to present a new model for climate change education called the wind turbine model. This model is designed to fill the gap between existing environmental and sustainability education models, which are not specific enough to address the complex and multifaceted nature of climate change. The wind turbine model uses the gearbox and generator of a wind turbine to represent the knowledge and thinking skills necessary for climate change education. The model also emphasizes the importance of critical evaluation and analysis of environmental information.

The article further states that the wind turbine model will be evaluated through research data gathered from climate change education experts. The Sustainable Development Agenda to 2030, which includes 17 interlinked goals and 169 targets for a sustainable future, is also mentioned as a relevant framework for addressing climate change. The goals include ending poverty, protecting the planet, and promoting sustainable energy and inclusive societies, among others [14]. Understanding the interlinkages and integrated nature of the SDGs is crucial to realize the targets set by the agenda 2030 [15] Synergy and trade-off among different developmental goals shall be reflected in designing coherent policies among different sectors [16], for the achievement of sustainable development. However, climate change is considered as

one of the eminent perils to sustainable development worldwide [17], as it causes extensive and unprecedented effects and unduly burdens the poorest and most highly susceptible countries [18].

According to Mosquera-Losada (2012) [19], the least developed countries (LDCs) are among the most vulnerable to the impacts of climate change and are at the forefront of the climate crisis, despite having contributed very little to the problem. This vulnerability is expected to hinder LDCs' ability to achieve the Sustainable Development Goals (SDGs) related to poverty, hunger, health, water, growth, infrastructure, cities, water resources, and ecosystems [20], as they have limited capacity to adapt to the changes.

It might also make it harder for LDCs to achieve their goals in terms of implementation, peace, sustainable consumption and production, gender equality, and education [21]. The Special Report on Global warming of 1.5 ∘C (IPCC, 2019) [22] highlights the importance of limiting global warming to 1.5 ∘C rather than 2 ∘C above the pre-industrial level in achieving various features of sustainable development [23]. Climate change adaptation and mitigation, the two lines of defense against climate change, have been found to have varying levels of synergy with other SDGs, including food security, poverty, equity, energy, water, and nutrient input in agriculture [24]. Properly addressing SDG 13, which concerns urgent action to combat climate change and its impacts, can effectively lead to achieving other SDGs [25]. Given the importance of climate change action, this research aims to provide a model for how family and friends can take action on climate change.

II. Literature Review

A. *The turbine model for climate change with family*

The climate change action model by Family and Friends (Figure 1) is presented as a turbine, because climate change action, like a turbine, is an entity that needs all its components to work together and reduce the harmful effects of this environmental problem.

Moreover, it's worth noting that the turbine model is designed to be in continuous motion, requiring constant user engagement. Additionally, as a visual aid, the model and its accompanying metaphor are both highly memorable. The various parts of the turbine are easily recognizable and well-known, and the turbine itself is viewed as an environmentally sustainable means of cleaning fuel. The development of this turbine model involved an examination of the various components identified in previous research literature as crucial to effective climate change education. A summary of the literature's key points is provided below.

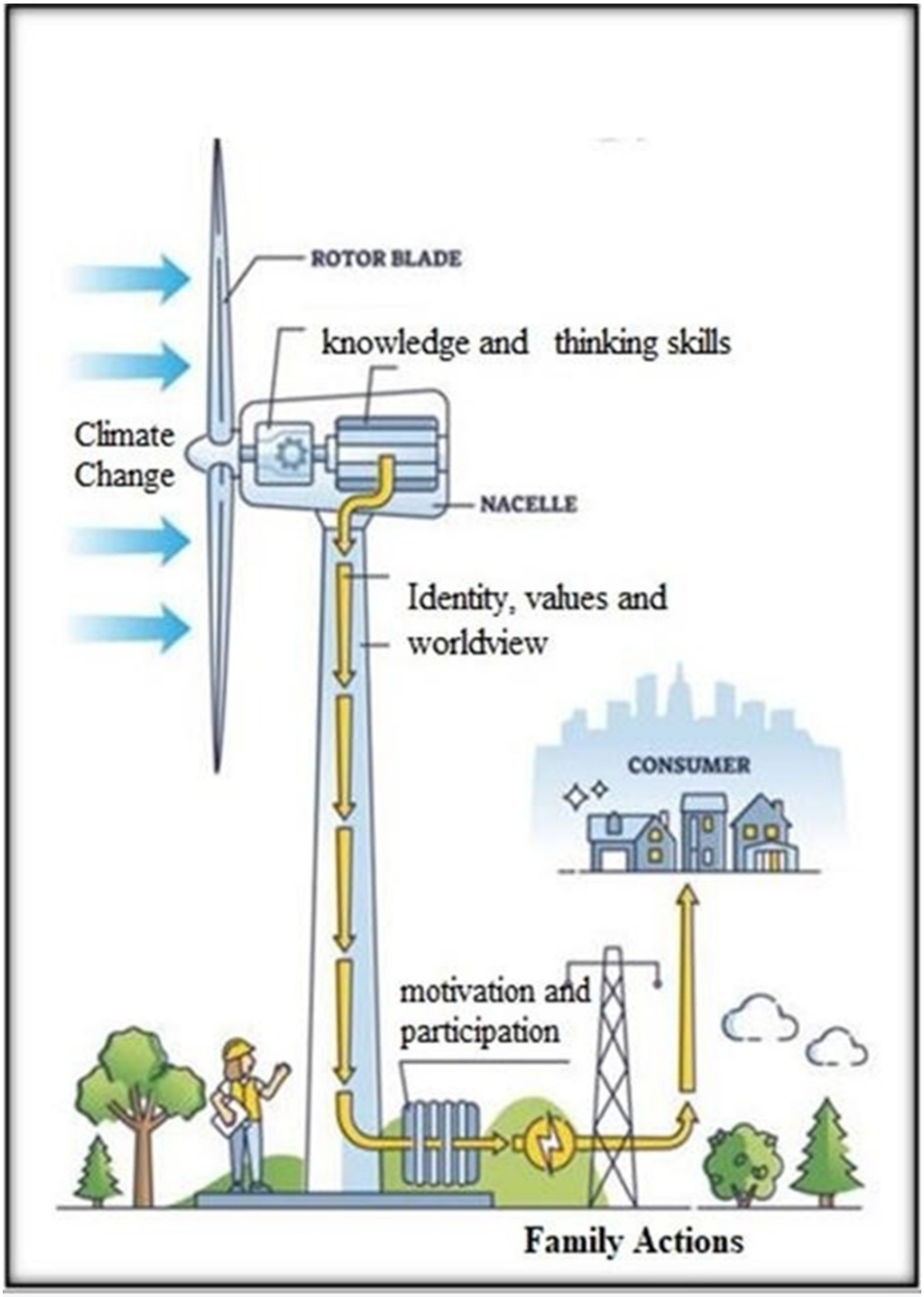

Figure 1. The Turbine Model On Climate Change Education (Authors)

B. *Gearbox and generator: knowledge and thinking skills*

The gearbox and generator are integral components for the production of power in order to address climate change, particularly in relation to wind power. Without these components, a turbine cannot function effectively. In the climate change education model, the gearbox and generator are symbolic of the knowledge and thinking skills that are necessary for effective climate change education. While knowledge is undoubtedly crucial, the ultimate goal of climate change

education should not be limited to acquiring more information. Instead, it should serve as a means to an end, facilitating critical analysis and a deeper understanding of environmental issues. According to Shepardson et al. (2012), at least the following aspects of knowledge should be studied in climate change education: (i) natural causes and changes in the climate system, (ii) atmosphere and pollution, (iii) amounts of snow and ice, (iv) oceans (sea level, temperature and life), (v) soil and vegetation and (vi) impact on humans. The importance of the gearbox and generator in the production of power to address climate change cannot be overstated. As such, these components serve as symbols for the knowledge and thinking skills that are fundamental to climate change education. It is important to note, however, that while knowledge is undoubtedly a crucial aspect of climate change education, it should not be viewed as an end in itself. Rather, it should serve as a means to an end, facilitating critical analysis and deeper understanding of environmental issues. By analyzing environmental information critically, individuals can gain a more nuanced and comprehensive understanding of climate change and the actions necessary to mitigate its effects. According to Shepardson et al. (2012), at least the following aspects of knowledge should be studied in climate change education: (i) natural causes and changes in the climate system, (ii) atmosphere and pollution, (iii) amounts of snow and ice, (iv) oceans (sea level, temperature and life), (v) soil and vegetation and (vi) impact on humans. They also point out.

Wheels: The Gearbox and generator are crucial components for producing power to address climate changes caused by wind. Without them, a turbine would not function. Therefore, in the climate change education model, the Gearbox and generator represent knowledge and thinking skills that are necessary for climate change education. While knowledge is essential, the goal of climate change education should not be solely to acquire more knowledge, but rather, to use it as a means to an end. Environmental information must also be analyzed critically and utilized to gain a deeper understanding. According to Shepardson et al. (2012), at least the following aspects of knowledge should be studied in climate change education: (i) natural causes and changes in the climate system, (ii) atmosphere and pollution, (iii) amounts of snow and ice, (iv) oceans (sea level, temperature and life), (v) soil and vegetation and (vi) impact on humans. They also point out.The importance of critical evaluation and application of climate-related information is emphasized, as simply acquiring knowledge is not enough. Therefore, in the climate change education model, the Gearbox and generator, representing knowledge and thinking skills, are given equal importance. Thinking skills can be cultivated through various means, such as reflecting on personal values, engaging in exploratory learning, taking action for the environment, and comparing and analyzing different types of texts related to a particular issue [26]. In addition, it is important to recognize the political and economic dimensions of climate change and to have open discussions about the intentions behind spreading information related to it. It has been suggested that analyzing texts that challenge the reality of climate change with scientific data can not only promote critical thinking skills, but also affect students' perceptions of climate change. Therefore, incorporating critical thinking skills and analyzing climate-related information with a scientific lens is crucial for effective climate change education [27]. In summary, climate change education should be taught to help students: (i) think critically, systematically and appropriately, (ii) tolerate uncertainty, (iii) assess values and behavioral habits of the students and their surrounding society, (iv) create and reflect on alternative future scenarios and (v) affect their own and society's future [27][28].However, climate-related information alone is worthless if it is not used, applied or critically evaluated. For this reason, Gearbox and generator of the model – knowledge and thinking skills – are the same size. Thinking skills can be developed by reflecting on values, exploratory learning, acting for the environment and comparing different types of texts on a particular

issue [26].Climate change is a complex issue that has various political and economic implications, which makes it important to understand and discuss how information about it is spread. Some scholars argue that using scientific data to analyze texts that question the reality of climate change can help promote critical thinking skills and influence students' perceptions of the issue. It is therefore essential to approach climate change education with a critical and analytical mindset, and to consider the various factors that influence the way information about climate change is presented and perceived [27]. In summary, climate change education should be taught to help students: (i) think critically, systematically and appropriately, (ii) tolerate uncertainty, (iii) assess values and behavioral habits of the students and their surrounding society, (iv) create and reflect on alternative future scenarios and (v) affect their own and society's future[27][28].you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

C. *Power Cables and Tower: identity, values and worldview*

The foundation of climate change education lies in the identity, values, and worldview of the learner. As new knowledge and skills are acquired, they become integrated into this frame. Climate change is a complex issue that touches on many aspects of humanity, society, culture, and ethics that are often overlooked in traditional education. Therefore, it is important to incorporate a holistic approach that takes into account these different dimensions and encourages learners to critically reflect on their own values and assumptions. Through such an approach, learners can develop a deeper understanding of the complexities of climate change and the ways in which they can contribute to a more sustainable future [29]. However, students are often interested in the ethical issues of climate change and show a desire to look at environmental issues from many different perspectives [30].The wicked nature of climate change is reflected in conflicts of value. The discussion on values should be comprehensive, at least from the point of view of human dignity and equality: should everyone, for example, have the same opportunities for success and prosperity, and if so, why are we depriving each other? [31] Increasingly central to climate change education is thinking about the role and identity of human beings as consumers and as the ones who cause environmental problems. It is also essential to ask whether students are given the opportunity to act towards climate change mitigation [32] and to consider what is termed as 'sustainability' and 'well-being' in climate change education. Many, including teachers themselves, hope for sustainable development but do not want to give up their own habits or consuming lifestyle[32]. Therefore, in addition to thinking about what people want to keep, in climate change education it is at least as important to think about what they are willing to give up.

D. *Power Cables and Tower: identity, values and worldview*

The identity, values and worldview of a learner create the foundation for climate change education. New knowledge and skills will also be attached to the frame they form. Climate change raises issues related to humanity, society, culture and ethics that are often excluded in education [29]. However, students are often interested in the ethical issues of climate change and show a desire to look at environmental issues from many different perspectives [30].The wicked nature of climate change is reflected in conflicts of value. The discussion on values should be comprehensive, at least from the point of view of human dignity and equality: should everyone, for example, have the same opportunities for success and prosperity, and if so, why are we depriving each other? [31][32].Increasingly central to climate change education is thinking

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E. *Transformer: motivation and participation*

Recent research suggests that climate change is not perceived as a concern among young male students, who feel powerless to contribute towards mitigating its effects. To promote climate change education, it is crucial to avoid presenting the topic as too distant or complex to understand. Instead, we should highlight the fact that individuals make up society and can therefore work towards changing it. Collaborative efforts are key to addressing climate change, even if it means starting with a single turbine to keep things simple. It is important to recognize that the opinions of others can significantly impact motivation, and families should be encouraged to engage in positive action together while supporting each other's participation. Home and school environments provide great opportunities to foster a sense of community and encourage positive engagement. Additionally, structural solutions can also aid in promoting motivation and inclusion, with school principals and municipalities playing a crucial role in achieving sustainable development goals in educational institutions.

III. Switchyard: Family Actions

The following actions were identified in this section for family education by the UN Climate Actions social network, with corresponding numbers assigned for easier reference:

Action number one is to support a Goal 13 charity by making a donation, no matter how small, to contribute towards climate change mitigation efforts.

Recycling paper, glass, plastic, metal, and old electronics is action number two.

The third action is composting food scraps to reduce climate impact and recycle nutrients.

Action number four involves choosing reusable products, such as eco-bags for shopping, and using a reusable water bottle or cup to reduce plastic waste.

The fifth action is to buy eco-friendly products and read packaging to determine if they are produced in an environmentally friendly manner.

Biking, walking, or taking public transportation instead of driving alone is the sixth action to reduce carbon emissions.

Action number seven is consuming less meat and becoming a vegetarian for one day a week to reduce the impact of the meat production industry on the environment.

Action number eight involves reducing paper use by avoiding printing and substituting it with electronic devices or carriers. It also recommends adopting pets from local animal shelters instead of shopping for them.

The ninth action is to offset carbon emissions by calculating one's carbon footprint and purchasing climate credits from Climate Neutral Now.

The final action is to stay informed by following local news and staying in touch with the Global Goals on social media or online, with the handle @TheGlobalGoals.

Here we show climate change actions as A1, A2, …. Then we prioritized these actions with Expert Choice software (AHP method). For this, we consulted 15 experts. Table 1. It shows the weight and priority of measures to deal with climate change. Also, Figure 2 shows the priority of climate change measures in Expert Choice.

Action	Weight	Priority
A1	0.050	10
A2	0.110	3
A3	0.076	8
A4	0.096	4
A5	0.095	5
A6	0.175	1
A7	0.152	2
A8	0.083	7
A9	0.087	6
A10	0.075	9

Table 1. Prioritization and weighting of climate change measures (in terms of environmental education in social networks) (authors)

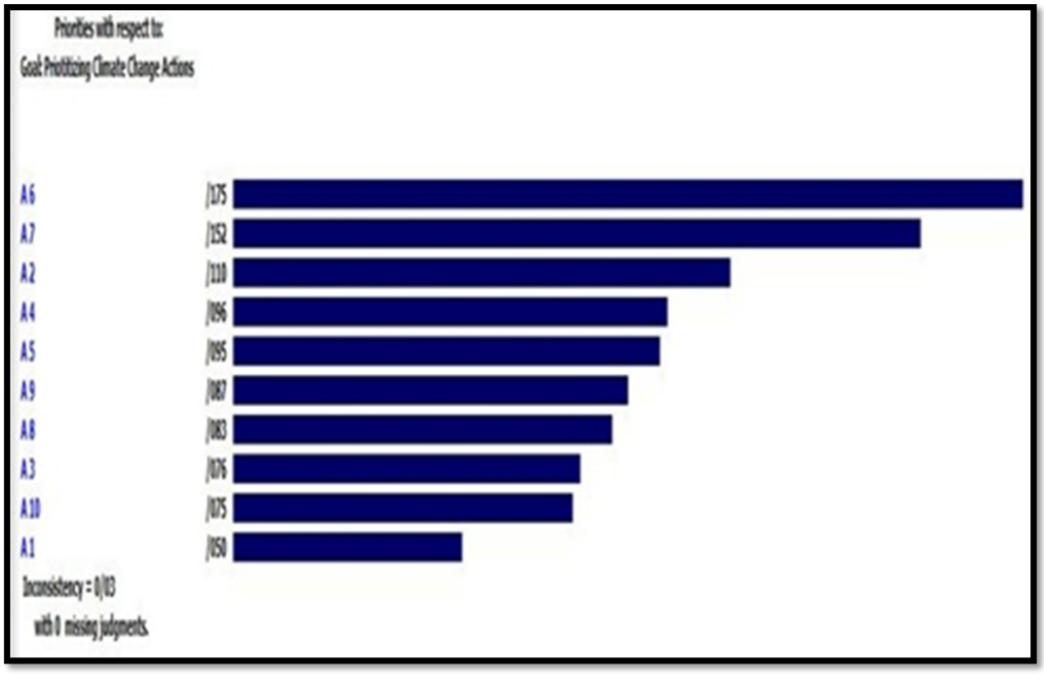

Figure 2. Weighting of climate change measures by Expert Choice software

IV. Usefulness and Suggestions for Improving the Turbine Model

Many experts in climate education have highlighted the importance of role models in their work towards sustainability education. In comparison to Joy Palmer's environmental education atmospheric tree model [33], the wind turbine model is updated to include ideas of future orientation, operational barriers to action, and emotions such as hope. Based on recent research, current events, and the general atmosphere of society, these educational aspects have become more crucial. Feedback on the turbine model indicates that it also evokes many symbolic ideas and inspires imagination. A more detailed analysis of the data shows that suggestions for improving the model can be grouped into three categories: (1) the number of turbine parts and their relationship to each other, (2) the role of the turbine in clean energy and participation, and (3) the role of support infrastructure for climate change educators. Experts cannot clearly identify which parts of the model are unnecessary, although there is consensus that climate change barriers are significant. It was also noted that some parts of the model overlap, which is inevitable for a model that aims to represent a holistic approach. Therefore, it may not be reasonable to remove a component entirely. Similarly, addressing climate change mitigation is related to aspects of knowledge, thinking skills, values, identity, and worldview. However, since each component has distinct characteristics, combining them into a single category does not help to express their unique nature. One of the proposed ways to develop the model is to add a bell, which can represent creating noise or lobbying and drawing attention to climate change education in society.

Since we have a wide range of turbines, perhaps several models are needed to teach climate change as well. According to experts, one of the main disadvantages of this model is the lack of social and social aspects. Although these aspects are implicit in the model in components such as knowledge, motivation and action, they can be emphasized by modifying the turbine. This model was developed to capture the holistic nature of climate change education and to highlight how its

various aspects are connected. As the results show, using the wind turbine metaphor helps illustrate the complex nature of climate change education and, more broadly, sustainability education. Some informal discussions with experts have indicated that the model has already helped them formulate a structure for climate education lectures. This model has also been used as an evaluation tool for the in-service training course for teachers regarding the goals of the 2030 agenda. this example, a tool was used to examine the themes and content of the course: were there elements of knowledge and thinking skills? How the worldview and values of the course participants were considered in the course activities? Were there different types of action and teamwork to motivate the participants? Were the views of the future and the emotions in the topics of the course? With the same idea of assessment, this model can be used as a tool to develop teacher training courses, examine classroom performance when dealing with climate education, and evaluate how curricula meet the needs of climate change education. The results of this study show that this model makes a useful contribution to climate change education, and although this model has shortcomings, experts consider it to stimulate them and stimulate new thoughts about the nature of climate change education. This model is also a rich educational reflection on what should be prioritized and considered in the field of sustainability. For example, a university lecturer described how recently in his class, some students started crying during a lecture on sustainability issues. The teacher said that previously her lectures were mostly filled with scientific knowledge, but now she has to consider other aspects of climate education, such as the emotions of her students. The turbine model can help teachers to remember different aspects of climate education in planning and teaching.

The results of the study indicate that the turbine model, which was initially designed for climate change education, can also be useful for broader applications in environmental and sustainability education. This outcome was somewhat unexpected, as the model was not originally intended to be used in these areas. Rather, it was created to address the inadequacy of existing models for teaching climate change, with the expectation that the new model would include elements not relevant to environmental or sustainability education in general. Nonetheless, the research suggests that the challenges associated with many environmental issues are complex and multidisciplinary, similar to those of climate change. Thus, the turbine model's ability to integrate various dimensions, such as emotions and values, may make it applicable to other areas of environmental and sustainability education. Although not all aspects of the model may be relevant to all areas of sustainability or environmental education, the study participants generally agreed that the model could be useful for various topics, including energy consumption. (eg, hope and other emotions) The model can potentially be useful for addressing challenges in environmental and sustainability education in a comprehensive way. Although not all aspects of the model are applicable to all areas of environmental education, the study participants agree that the model can be applied. For instance, in the case of energy consumption issues, several dimensions of the turbine model should be considered during training, such as values and action. The study also suggests some ways to improve the model. Some experts believe that climate change barriers are unnecessary and should be removed from the model, but the authors argue against it for three reasons. One main reason is that evidence shows that people are more likely to change their behavior when they are aware of the barriers to it. [34] Also, understanding common obstacles can help people understand each other, our shortcomings and how we can move forward together The turbine model developed for climate change education may have broader applications in environmental and sustainability education. The model's

various dimensions, such as values and action, can be relevant in addressing multifaceted challenges like energy consumption. While some experts suggest that the barriers to climate change behavior should be removed from the model, the authors argue that understanding and addressing these barriers are crucial for promoting behavior change. Moreover, discussing these barriers can have a significant social impact, as seen in discussions among politicians, scientists, and economists about solutions to climate change. The model can also be developed to emphasize the social and community aspects of climate change education, which is essential and can be illustrated by drawing several turbines together. Overall, the model can be a useful tool for teacher training, curriculum development, and evaluating sustainability education training courses. The ultimate goal is to promote comprehensive climate change education and foster sustainability on our planet.

V. Conclusion

This paper introduces and evaluates the wind turbine model, a comprehensive approach to climate change education that was developed based on an extensive literature review. The wind turbine model emphasizes the importance of several key aspects of climate change education, including knowledge, thinking skills, values, identity, worldview, action, motivation, participation, future orientation, hope, and operational barriers.

The wind turbine model uses wind as a metaphor for climate change, and the turbine is presented not as a means of production, but as a means of dealing with the effects of climate change. Each component of the wind turbine, such as the generator, gearbox, and transformer, is considered part of a system to promote knowledge about climate change.

Additionally, environmental attitudes and behaviors in families are taken into account, and the model is recommended for environmental education through social networks.

Overall, the wind turbine model offers a holistic and comprehensive approach to climate change education. It recognizes the importance of promoting knowledge and taking action to address the effects of climate change, as well as the role that personal values, identity, and worldview play in shaping our attitudes towards the environment. By focusing on operational barriers and promoting hope and future orientation, the wind turbine model encourages individuals and communities to work towards a more sustainable future.

After providing measures to tackle climate change, they were ranked. These findings also provide insights into professionals' perceptions of climate education. Finally, the paper discusses how to further develop this model.

Based on the results of the United Nations measures for family education for climate change were prioritized, based on which, the order of education in the headings is as follows:

1. Recycle paper, glass, plastic, metal and old electronics.
2. Bike, walk or take public transport. Save the car trips for when you’ve got a big group.
3. Consume less meat and become vegetarian for one day a week. The meat production industry has a huge impact on the environment.

The article drew a parallel between climate change and wind and proposed the use of the wind turbine model and its various components to address the issue. The objective was to demonstrate that a threat such as climate change could be turned into an opportunity. It is worth noting that wind energy, which includes the wind turbine model, is closely linked to climate change.

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