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Evaluating the Effect of School-Based Air Pollution Education on Students' Knowledge and Protective Behaviors

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Abstract

Air pollution is among the most important environmental issues, posing a threat to human health, especially children, who are more susceptible to the physiological and behavioural effects of the environment. Schools are an ideal setting for promoting environmental literacy and developing protective behaviours, but there is limited empirical evidence on the effectiveness of school-based air pollution education programs. This paper evaluates the impact of a school-based educational intervention on students' knowledge of air pollution and their behavioural changes in protective behaviours. A quasi-experimental pre-test and post-

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test design was used in this study, and both the intervention and control groups were selected from urban schools exposed to different levels of ambient air pollution. The intervention comprised a structured learning program on air pollution sources, health impacts, interpretation of the Air Quality Index (AQI), and practical self-defensive actions, delivered over four weeks through interactive lectures, visual media, and participatory activities. The intervention was informed by the need to gather data using a validated knowledge assessment scale and a behavioural adoption questionnaire, which were administered prior to the start of the intervention and upon its completion. The difference in the knowledge and behaviour was also analysed using t-tests paired and analysis of variance (ANOVA) and the effect sizes were shown to demonstrate the influence. The findings show that students' knowledge of air pollution has improved significantly, and protective behaviours, including frequent AQI checks, mask use, and avoiding high-pollution areas, have also increased. The findings have demonstrated that environmental education in schools can be adopted as an effective tool of enhancing environmental awareness, adaptive behaviours and facilitate broader public health and sustainability goals. Another necessity presented in this paper is the introduction of air pollution education into official programs, and it explains why educational establishments should be viewed as key players in maintaining environmental stability among young generations.

Keywords:

Air pollution education, environmental literacy, student behaviour, school-based intervention, public health, sustainability.

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Introduction

Air pollution has become one of the most acute environmental and community health issues of the twenty-first century, with far-reaching consequences for the ecosystem, urban infrastructure, and human health (Reyes-Marcelino et al., 2021). Sifting industrialization, urbanization, automobile emissions, biomass burning, and unsustainable energy consumption have led to poor air quality in many places, especially in densely populated urban and peri-urban centres (Chokprajakchad et al., 2025). High concentrations of particulate matter (PM 2.5 and PM 1.0), nitrogen oxides, sulphur dioxide, and other dangerous pollutants are associated with respiratory and cardiovascular diseases, cognitive impairment, and a lower quality of life. In addition to its impact on human health, air pollution negatively affects biodiversity, soil fertility, crop productivity, and environmental sustainability, thereby disrupting the ecological balance and the resilience of natural systems (Cho et al., 2023; Kigarura, 2024). Children are particularly susceptible to air pollution because they are more exposed to air pollutants than any other population group, due to their developing respiratory and immune systems, frequent breathing relative to their body size, and greater exposure primarily during outdoor activities. Excessive exposure to polluted air in childhood has been associated with an increased risk of asthma, poor lung development, and chronic health problems (Strong et al., 2025). Meanwhile, children themselves can be considered crucial agents of environmental consciousness and transformation, as attitudes, values, and behaviours formed in childhood may influence environmental behaviour in adulthood (Isenaj et al., 2025). Consequently, educating students about air pollution and developing defensive behaviours is not merely a social health need but also an economic investment in future environmental management (Prashanth, 2025). Schools are important arenas for environmental intervention and behaviour change because they are formal learning contexts where scientific knowledge, risk awareness, and pro-environmental attitudes can be developed systematically. Environmental education in schools can help close the divide between science and practice by translating complex environmental science into practical knowledge. Schools can influence how students perceive environmental risks and adopt protective behaviours by encouraging behavioural changes to

reduce exposure during periods of high pollution, and by using interactive pedagogies, experiential learning, and community engagement to promote cleaner environments (Fernandes et al., 2023). Despite the identified significance of environmental education, there remains a scarcity of empirical studies that carefully assess the effectiveness of school-based air pollution education in enhancing students' knowledge and practical protective behaviours. Most of the literature has focused on awareness outcomes, and little effort is made to quantify behavioural change (Flood et al., 2020). The identified gap explains why educational interventions that connect environmental literacy with practical, health-protective behaviours need to be systematically evaluated.

Research Questions

1. Do school-based air pollution education and awareness create a significant improvement on the knowledge of air pollution among students?
2. Do the educational intervention participants exhibit changes in protective behaviours?
3. Do the results of students who received the intervention and students in the control group differ significantly with respect to results?

Objectives

- To determine the level of baseline knowledge of the health risk and air pollution among school students.
- In order to design and execute a planned educational intervention about air pollution in schools.
- To observe the differences in the level of knowledge of the students prior to and after the intervention.
- To measure the effect of the intervention on the protective behaviour of students.
- To compare the results in intervention and control groups to establish effectiveness.

The organization of the paper is the following one. Section 1 presents air pollution as a pressing environmental and health issue, explains children's susceptibility, explains why schools are important settings for environmental intervention, and states the purpose, goals, and research questions of the study. Section 2 is a review of the literature on air pollution, environmental education in schools, and the knowledge-behaviour relationship with major identified research gaps. In section 3, the conceptual framework which interrelates school-based education with knowledge enhancement and adoption of protective behaviours is presented. Section 4 outlines the methodology, including the research design, study setting, study participants, educational intervention, measurement tools, and statistical analysis. The empirical findings on changes in students' knowledge and behaviours are presented in Section 5 presents the results, showing significant improvements in students' knowledge and protective behaviours. Section 6 discusses the implications of the findings, emphasising the role of schools in fostering environmental resilience and the need to integrate air pollution education into policy. Finally, Section 7 concludes the study with a summary of its contributions and a description of future research directions.

Literature Review

Air Pollution and Human–Environmental Systems

The research is important for environmental sustainability and education policy by providing empirical evidence on the effects of school-based learning on the development of environmental literacy and health-conscious behaviour. The findings would guide the curriculum, facilitate the integration of air quality education into the formal education system, and inform policy actions to build climate and pollution resilience among younger population groups. Linking environmental understanding with behavioural adjustment, the paper strengthens the nexus between learning and population health, as well as between sustainable urban living and the broader interests of conserving the environment and promoting human well-being.

Environmental Education in Schools

Environmental education is considered an indispensable component of sustainable development and is expected to produce environmentally conscious citizens who can make pro-environmental choices. The schools are at the core of this process because they provide a formal learning experience in which scientific knowledge, ethical values, and civic responsibility can be integrated into the curricula (Tallon et al., 2021). As the extensive research demonstrates, environmental education not only raises students' awareness of ecological problems and fosters understanding of the connections between humans and the environment, but also promotes positive attitudes towards conservation and sustainability (Ramadani et al., 2023). Education, built on a foundation of real-world learning, discussion, and problem-solving, has been particularly useful in attracting students and in improving long-term understanding of environmental concepts. Research also suggests that early life environmental education could be one way of shaping attitudes and behaviors throughout life, and there is a need to incorporate the messages of sustainability at the basic education level (primary) and secondary education (Hashemian et al., 2022).Programs focusing on local environmental problems, such as air quality or water pollution, are likely to be more effective with students because they can connect abstract scientific concepts to real-life situations. Despite this accumulating evidence, most of the available literature focuses more on attitudinal than on actual behavioural change, leaving unanswered questions about the extent to which school-based learning translates into real-world environmental practice (Kebede et al., 2020).

Knowledge–Behaviour Relationship

There is a large body of literature on the relationship between environmental knowledge and behaviour that tends to imply that one must be sufficiently aware before taking pro-environmental action (Syah et al., 2021). Environmental psychology and education research show that the more environmentally literate a person is, the more he/she will practice protective behaviours, such as turning down energy use, producing less waste, or avoiding exposure to environmental hazards (Olaboye et al., 2024). As far as air pollution is concerned, purchasing health risks and mitigation strategies have been associated with practices such as the use of protective masks, monitoring air pollution levels, and limiting outdoor activities during high pollution periods (Mationg et al., 2020). These findings indicate that education can be the motivation in the behavioural adaptation. However, knowledge is not always a guarantee of behavioural change, since a number of contextual, social, and psychological factors shape decisions. Economic constraints, cultural beliefs, perceived inconvenience, and resource availability can slow the translation of knowledge into action. Moreover, perceptions of risk, individual motivation, and trust in information sources are critical factors in shaping behavioural responses to environmental threats (Xu et al., 2020). This knowledge-to-practice gap underscores

the need for educational interventions that go beyond the dissemination of information and the activation of behavioural skills, critical thinking, and empowerment.

Research Gap

Although the importance of environmental education and its influence on air quality education awareness are appreciated, there is a substantial gap in empirical research that analytically evaluates the efficacy of school-based air quality education in terms of quantifiable behavioural consequences. The available literature comprises a wide range of articles that base their conclusions on self-reported attitudes or general awareness of the environment rather than on a systematic assessment of students' protective behaviours. There are not many interventions based on a firm experimental or quasi-experimental design incorporating control groups, pre- and post-test and statistical validation of behavioural change. Secondly, very minimal focus has been given to integrating air quality education as a formal part of school education in a systematic and scalable manner. The limitations outlined above are why such a study is necessary to determine a clear relationship between school education programs and knowledge acquisition, and realistic behaviour adjustments in a real-life pollution setting. Closing this gap will be essential to promoting evidence-based policies in education, building environmental resilience, and transforming schools into not only learning institutions but also agents of sustainable change.

Conceptual Framework

The theoretical approach used in the study is also systems-based and incorporates the concepts of education, environment, health, and sustainability. The model presupposes that air pollution education in schools is a stimulus to a more inclusive human-environment complex and leads to a chronological process of cognitive, psychological, and behavioural transformation that will yield healthier populations and sustainable environmental conditions. This framework does not view education as a one-way pedagogical process, but rather as a convergence among students, the immediate environment, and the wider socio-ecological context. The framework is based on school education and it is the primary intervention mechanism. The structured curriculum, interactive teaching, and experiential learning expose students to scientifically based information on the causes of air pollution, its effects on human health, and methods to reduce it. This kind of pedagogical contribution can likely raise environmental literacy by enabling students to better grasp the intricacy of air pollution and its impact on human and ecological systems. It is assumed that greater knowledge can affect risk perception, as students will be more aware of the personal and societal risks associated with poor air quality. The risk perception will likely lead to a shift in attitude, characterized by greater attention to environmental protection and responsibility, as well as a greater willingness to take preventive actions. This attitudinal change is a highly important intermediate step that lies between cognitive awareness and behavioural response. The model thereafter connects shift in attitude to the regimentation of protective behaviours, including constant checking of the Air Quality Index (AQI), utilisation of protective masks in times of excessive pollutants, that is, without going to polluted places and the encouragement of cleaner surroundings in their respective communities. These are the behaviours that are considered real, quantifiable consequences of the educational intervention, the indices of working knowledge of the environment. Lastly, the sum total of these behavioural changes should lead to better health and environmental results. At the individual level, students will be less exposed to harmful pollutants, which can minimize health risks. On a group scale, a culture of environmental responsibility can be achieved through increased environmental awareness and active behaviours, and can support broader sustainability goals, such as cleaner air, healthier environments, and more resilient urbanism. It is in this theoretical context that the idea of schools as strategic agents of sustainable change gains force

since through this theoretically-grounded direction, education can finally result in positive environmental and health outcomes.

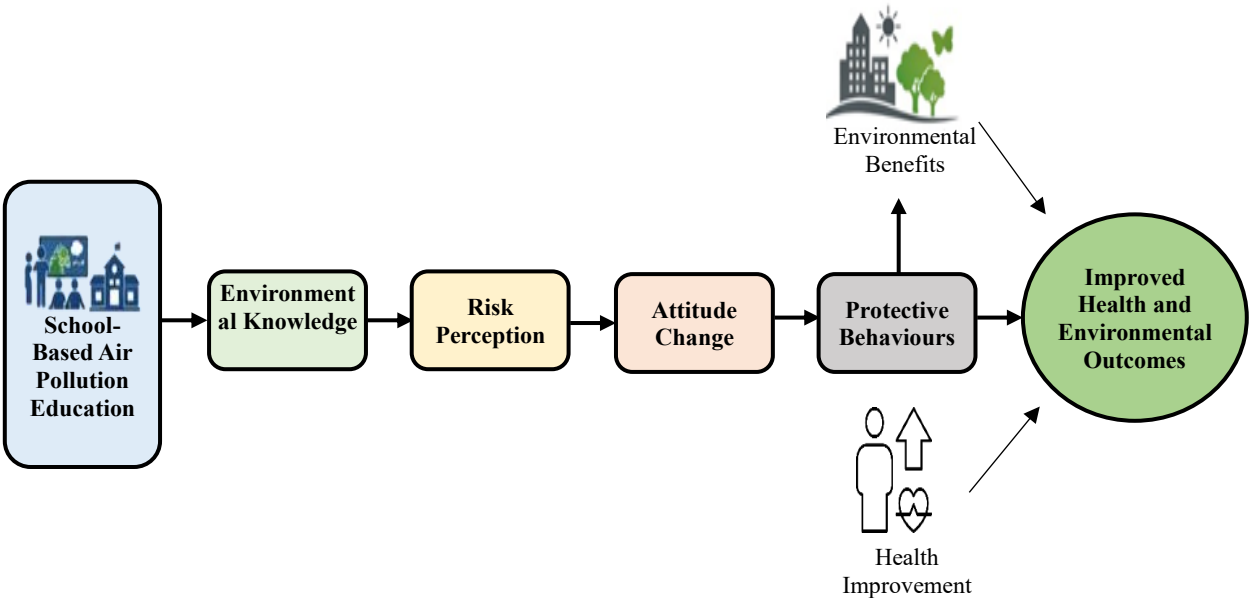

Figure 1. Conceptual framework of school-based air pollution education and behavioural adaptation

Figure 1 demonstrates that school-based air pollution education is on the conceptual pathway to environmental and health outcomes. The model demonstrates a step-by-step process in which the educational intervention results in improved environmental knowledge, risk perception, attitudinal change, and the adoption of protective behaviours, eventually leading to improvements in public health and environmental sustainability. The model is based on the interdependence of education, human behaviour, and ecological wellbeing within a whole socio-environmental system.

Methodology

Study Design

The research design was a quasi-experimental pre-post-trial with an intervention and control group, which is deemed to be the right method of conducting research on the evaluation of educational programs used in school life. This design may be applied to determine changes in students' knowledge and behaviours over time, as well as to compare the outcomes of students subjected to the educational intervention with those of students in the normal curriculum. The level of change caused by the program was determined by establishing baseline measurements for both groups before and after the intervention to assess each group's change. Internal validity is enhanced by the use of a control group, which accounts for external factors such as general environmental awareness or media exposure at the time of the study.

Study Setting

The research was conducted in selected urban and semi-urban schools in regions with moderate to high ambient air pollution. The selection of such places was based on environmental relevance, including proximity to major road networks, industrial areas, and areas with high population density and high Air Quality Index (AQI) levels. The selection of settings ensured that students were directly or indirectly exposed to air pollution, thereby making the educational intervention contextually fitting and applicable. The schools were matched in

terms of infrastructure, student demographics, and academic environment to reduce contextual bias between the intervention and control sites.

Participants

The respondents were middle and high school students aged 12 to 16, a developmental phase during which environmental awareness and behavioural patterns are in the process of development. The schools were selected through a purposive sampling strategy, and, where possible, students in each school were randomly assigned to intervention or control groups. Statistical power was used to determine the sample size, as the research question aimed to detect significant differences in pre- and post-intervention scores, based on expected effect sizes from prior environmental education research. Ethical compliance and voluntary participation were ensured through parental consent and school administrative approval before data collection.

Educational Intervention

The learning activity consisted of a set of modules designed to enhance students' knowledge of air pollution and stimulate health-protective behaviours. The curriculum focused on four key themes: causes of air contamination, such as motorized transport, industrial activities, and biomass burning; health effects, such as the respiratory and cardiovascular risks; the meaning of the Air Quality Index (AQI) and its relevance in everyday life; and personal protective measures, such as using a mask and avoiding to be exposed to air pollution. Instructional methods were learner-centered and interactive, including classroom lectures, multimedia videos, visual posters, and facilitated group discussion to motivate students' interaction and critical thinking. The connection between scientific concepts and their experience in life was made through scientific concepts, real-life examples, and case studies of air pollution incidents. Moreover, some schools implemented mobile AQI applications to introduce students to real-time air quality monitoring, which strengthened the behavioural use of knowledge after leaving the classroom. The intervention was enacted over four weeks, conducted weekly with structured lessons and activities.

Measurement Tools

The effectiveness of the intervention was evaluated using two major instruments. Knowledge Scale: The air pollution sources, health hazards, and prevention methods were also assessed using a structured questionnaire that determined the students' knowledge of air pollution. The scale demonstrated content validity through multiple-choice and short-answer questions aligned with the educational modules. Cronbach's alpha was used to estimate reliability and assess internal consistency. Protective Behaviour Scale: A behavioural scale that assesses students' use of protective behaviours regarding air pollution. Evaluated practices included wearing a protective mask on high-pollution days, staying out of polluted neighbourhoods, checking the air quality index regularly, and getting involved in clean air awareness or advocacy. The responses were recorded on a Likert scale to determine the frequency and intensity of the behaviours.

Data Analysis

Quantitative data were analysed using the right statistical methods. Paired t-tests were conducted within each group to detect changes in knowledge and behaviour from pre- to post-intervention. The ANOVA was one-way and used to test differences between the intervention and control groups, and to determine the relative efficacy of the educational program. Effect sizes were computed to assess the degree of change and enhance the interpretability of the results in accordance with NES quality standards. Statistical significance was assessed at the 95% confidence level, and all tests were performed using standard statistical packages.

Results

Change in knowledge scores

The comparison of pre- and post-intervention data showed that air pollution levels among students increased significantly after the school-based learning program. There was an improvement in the mean knowledge score from 62.4 in the pre-intervention period to 81.6 in the post-intervention period. This is an improvement in understanding of the sources of pollution, health hazards, and the prevention measures introduced through the intervention. The scale of the change indicates that organized environmental instruction proved effective in enhancing students' environmental literacy rather than causing them to develop a shallow environmental awareness.

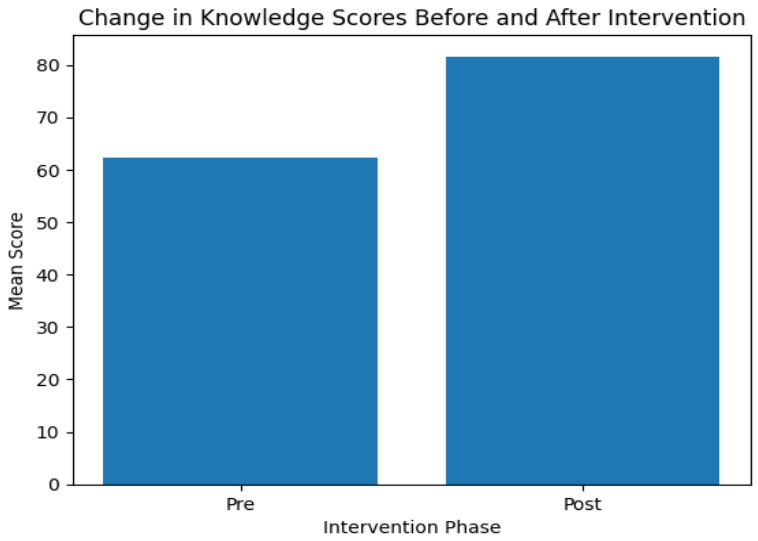

Figure 2. Change in knowledge scores before and after intervention

Figure 2 shows that the mean knowledge scores have significantly increased following the intervention, indicating that exposure to specific air pollution education significantly improved students' cognitive understanding of environmental risks.

Change in protective behaviours

There were also significant changes in students' behaviour after the educational intervention. The average score on protective behaviour rose by 17.5 points between the pre- and post-intervention as the mean of the post intervention was 76.2 as compared to pre intervention 58.7. There were reported changes in behaviour such as an increased checking of the Air Quality Index (AQI), wearing of protective masks on high-pollution days, avoidance of highly polluted places and increased attendance at clean-air awareness engagements. These results demonstrate that the intervention was not only effective at knowledge improvement but also conversion of learning into health-protective behaviours.

Comparison of Pre - Post Outcomes

Table 1. Comparison of pre- and post-intervention scores

Measure	Pre-Intervention Mean	Post-Intervention Mean	Mean Change
Knowledge Score	62.4	81.6	19.2
Protective Behaviour Score	58.7	76.2	17.5

The table 1 presents an overview of the improvements in the two outcome domains, which proves that the profit in knowledge was followed by a similar profit in protective behaviour. The fact that the magnitude of change in the measures is relatively similar indicates a high degree of relationship existing between cognitive learning and behavioural adaptation. Combined, the findings offer empirical data to support the idea that school-based air pollution education is capable of making quantifiable changes in the environmental knowledge and actual protective behaviours students. The patterns of steady increase in cognitive and behavioural indicators justify the success of air quality education introduction in the formal school learning as the means of advancing the general health, environmental and sustainable citizenship.

Discussion

The results of the present research clearly highlight the pivotal role that school-based environmental education plays in fostering improved environmental literacy and catalyzing behavioural change among students. The overall rapid improvement in the knowledge scores of the students shows that organized educational programs can be used to increase the knowledge of the students on environmental challenges, especially air pollution. This is in line with the sustainability theories that consider education as a foundation of raising responsible citizens who will make wise decisions when it comes to the environment. In addition to awareness awareness, the intervention encouraged a more profound attitude to the complex relationships between humans and the environment, which is critical in solving complex ecological problems. Cognitive benefits of environmental education did not end on what the learner was learning and this was indeed applied to protective behaviours through checking the Air Quality Index and wearing protective masks and had proven that education could be used to close the awareness-action gap. These findings help highlight the significance of environmental education that can be based on the context of the life of students and can be made more relevant to them in order to make them more proactive in reducing the risks associated with pollution.

In addition, the results outline the wider relevance of environmental education, particularly in urban and semi-urban areas where the air quality has a direct effect on the everyday life and well-being. Integrating knowledge and behaviour change provides the interrelated nature of learning and doing in promoting environmental resilience. The study also supports the notion that schools can act as catalysts for community-wide environmental change, with educated students likely to extend their protective behaviours to their homes and communities. The ability of schools to serve as hubs for real-time air quality monitoring and sustainability initiatives further strengthens their role in environmental governanceAt the policy level, the research recommends a more integrated way of integrating air pollution education in school curricula. Policymakers can be able to provide air quality literacy in science and environmental studies programmes to make sure that students are provided with the knowledge that is not only theoretical but also practical to manage air quality therefore increasing their capacity to be involved in processes of environmental decision making.

Finally, the study highlights the necessity of such collaboration between the school system, environmental organizations and local governments to enhance the viability of the environmental education practice. Such learning tools as mobile air quality apps can be based on experience, and students will have an opportunity to achieve a hands-on access to the real environmental data to further deepen their knowledge of the pollution and its consequences. A curricular shift that includes comprehensive air quality education, coupled with teacher training in environmental pedagogy, can foster a more uniform distribution of environmental knowledge across regions and socio-economic groups, reducing disparities in awareness and preparedness. Through air quality education, schools can enable the development of a generation of citizens who are socially conscious towards the environment and have the capacity to influence the creation of sustainable urban living, assist in the formulation of policies that help in controlling pollution, and help in the

establishment of resilient, habitable cities. This study thus brings out the revolution that schools can be and be as agents of environmental changes and the crucial way they are needed to make future generations who would be able to meet the global environmental issues.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

Conclusion

This paper posits the significant role of air pollution education in school to improve the environmental literacy and the health-protective behaviours in students, which successfully closes the knowledge-to-behaviour gap. The results demonstrate that structured educational interventions can significantly improve students' understanding of air pollution sources, health risks, and mitigation measures, leading to tangible changes in protective behaviours such as monitoring air quality, wearing masks, and avoiding highly polluted areas. The study will help highlight the importance of the school in the creation of environmental resilience and responsible and proactive citizens who are better placed to address environmental issues, by instilling critical knowledge in students. The results suggest that air pollution education should be included in the formal curricula, not only so that students understand the environmental problems but also because they should know how to prevent such problems in their everyday lives. Furthermore, the research recommends policy adjustments to integrate systematically air quality literacy in science and environmental studies programmes, i.e., environmental education became a part of the school curriculum. This would assist in the development of a generation of environmental conscious people who know the value of sustainable practices and are prepared to make a difference in the world around them. After all, the current study allows drawing the conclusion that schools are an extremely vital community that can develop future generations of people who will be able to overcome complex environmental and human health challenges and provide a healthier, cleaner, and more sustainable future to everyone. The future studies are advised to determine the long-term outcomes of air pollution education, combine online technologies with the purpose of improving learning, and extend the intervention to the rural population and relate it to the global climate problem.

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