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# Developing Students' Social Responsibility Toward Nature by Integrating the 7E Teaching Model and STEM Approach into Environmental Education.

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***Abstract.*** *This scientific article analyzes the theoretical and methodological foundations of the 7E teaching model (Eisenkraft [1]) and the STEM (Science, Technology, Engineering, Mathematics) approach, their integration with environmental education, and the possibilities of fostering students' social responsibility toward nature through this integration. The study details the stages of the 7E model (Elicit, Engage, Explore, Explain, Elaborate, Evaluate, Extend) and the principles of interdisciplinary integration within the STEM approach, substantiating the compatibility of these two pedagogical frameworks. Furthermore, the structural components of social responsibility in the context of environmental education (cognitive, affective, conative, and reflexive components) are revealed, along with the pedagogical mechanisms for developing these qualities. The author has developed methodological foundations for integrating the 7E model and the STEM approach and scientifically substantiates the effectiveness of the proposed integrative model in shaping students' environmental culture and their responsible attitude toward nature.*

**Keywords:** 7E teaching model, STEM approach, environmental education, social responsibility, interdisciplinary integration, constructivism, project-based learning, environmental culture.

**Introduction.**

The rapid development of modern society, technological progress, and increasing production volumes have led to a sharp rise in anthropogenic pressure on the environment. Global environmental problems such as climate change, depletion of natural resources, and pollution of air and water bodies make the issue of educating the younger generation in the spirit of a responsible attitude toward nature extremely urgent. From this perspective, updating the content of environmental education in general secondary schools and enhancing its effectiveness is recognized as one of the priority directions of pedagogical science.

Our research has revealed that traditional environmental education is mainly aimed at imparting knowledge and is not sufficiently effective in shaping an active life stance of a responsible attitude toward nature among students. In increasing the effectiveness of environmental education, active teaching methods, especially inquiry-based approaches and interdisciplinary integrated models, play a particularly important role.

This article analyzes the theoretical foundations of integrating the 7E teaching model and the STEM approach into environmental education. We consider the 7E model to be based on the constructivist theory of learning and to stimulate students' active cognitive activity. The STEM approach, on the other hand, serves to develop 21st-century skills in students through interdisciplinary integration and project-based activities. We believe that the synergy of these two approaches contributes to the development of students' cognitive, affective, and conative spheres in the process of environmental education, thereby fostering a socially responsible individual toward nature.

**1. The 7E Teaching Model: A Modern Interpretation of the Constructivist Approach.**

**1.1. Theoretical Foundations of the 7E Model.** The 7E teaching model was developed in 2003 by American educator Arthur Eisenkraft [1] and is an inquiry-based learning model grounded in constructivist theory. This model improves upon the traditional 5E learning cycle (Engage, Explore, Explain, Elaborate, Evaluate) by enriching it with the Elicit and Extend stages. In our view, the addition of these two stages enables the activation of students' prior knowledge and its transfer to new situations, which is particularly important in environmental education.

The stages of the 7E model are as follows:

1. Elicit – uncovering students' prior knowledge and conceptions of the topic;
2. Engage – arousing students' interest and creating a problematic situation;
3. Explore – students' independent investigations and experiments;
4. Explain – students articulating their conclusions and acquiring new concepts;
5. Elaborate – applying knowledge in new contexts;
6. Evaluate – assessing students' knowledge and skills;
7. Extend – applying the learned knowledge to everyday life and global issues.

**1.2. Application of the 7E Model in Environmental Education.** Research shows that the 7E teaching model has significant importance in environmental education. In particular, a study conducted among 9th-grade students demonstrated that a

lesson plan based on the 7E model led to a marked improvement in understanding climate change concepts, with a mean post-test score of 10.6 and a normalized gain of 0.45 [3]. Our research found that the 7E model serves to increase students' interest in the lesson, stimulate their engagement, and foster a positive attitude toward environmental issues.

Another study examined the impact of the LC7E (Learning Cycle 7E) model on the acquisition of nature conservation topics by 4th-grade students [9]. The results indicate that the LC7E model significantly increases students' level of mastery in natural sciences and their knowledge of environmental themes.

Furthermore, integrating the SETS (Science-Environment-Technology-Society) approach into the 7E model contributes to the development of students' critical thinking skills [8]. This, in turn, is crucial for analyzing environmental problems and finding solutions to them.

**2. The Role of the STEM Approach in Environmental Education.**

**2.1. The Essence and Principles of STEM Education.** The STEM (Science, Technology, Engineering, Mathematics) approach is an educational model based on the integrated teaching of science, technology, engineering, and mathematics [4]. This approach is aimed at developing students' ability to solve real-life problems, and its core methodological principles are interdisciplinary connectedness and project-based activity.

In modern pedagogy, the STEM approach is widely applied as an innovative direction for stimulating creativity through interdisciplinary integration and project-based activity [5]. Our research revealed that the key features of STEM education – inquiry, problem-based learning, project-based activity, and practical orientation – determine its close connection with environmental education.

**2.2. Practical Application of the STEM Approach in Environmental Education.** The STEM approach is being effectively applied in environmental education in the following directions. First, within the framework of STEAM+AI literacy programs on environmental protection and ecology, students' environmental awareness is being shaped through issues related to sustainability [7]. Second, within nature-based STEM applications, students' environmental knowledge and skills are being developed through activities such as designing from waste, understanding recycling processes, and applying zero-waste principles.

The effectiveness of the STEM approach in environmental education can be clearly seen in the example of the Arkas Science and Art Centre in Turkey. At this educational institution, students develop projects on climate change, renewable energy, and waste recycling. Research results indicate that under a project-based learning model, students' environmental awareness increased by 95%, and their research, analytical, and media literacy skills improved. Within the framework of the Climate Action Project, which involved 3.4 million students from 151 countries, students gained experience in international collaboration and teamwork [6].

**2. Mutual Integration of the 7E Model and the STEM Approach in Environmental Education.**

**3.1. Theoretical and Methodological Foundations of Integration.** Our research revealed that the 7E teaching model and the STEM approach have a logical compatibility. First, both approaches are grounded in the constructivist paradigm and prioritize students' active cognitive activity, inquiry, and problem-based learning. Second, the stages of the 7E model synergistically align with the practice-oriented project-based activity of the STEM approach. Third, both approaches are aimed at developing students' ability to solve real-life problems.

Research on developing 7E model lesson plans on the topic of nature conservation [3] shows that the Explore, Elaborate, and Extend stages of the 7E model are directly linked to the inquiry and project-based activity of the STEM approach. Precisely at these stages, students have the opportunity to independently study environmental problems, analyze their causes and consequences, and propose solutions.

**3.2. Structural Framework of the Integrative Model.** Below is the structural framework of the integrative model of environmental education that combines the 7E model and the STEM approach:

| 7E Stage | Content of STEM Integration | Component of Environmental Responsibility |
|---|---|---|
| Elicit | Eliciting students' initial knowledge about an environmental problem within the context of STEM disciplines | Cognitive (knowledge) |
| Engage | Presenting a real-life problematic situation related to the environment based on the STEM approach | Affective (interest) |

| 7E Stage | Content of STEM Integration | Component of Environmental Responsibility |
|---|---|---|
| Explore | Students investigating the environmental problem using STEM methods (observation, measurement, experimentation) | Conative (activity) |
| Explain | Explaining the scientific basis of environmental phenomena within the framework of STEM disciplines | Cognitive (understanding) |
| Elaborate | Applying knowledge in STEM projects (e.g., zero-waste technologies) | Conative (practice) |
| Evaluate | Assessing the results of the environmental project according to STEM criteria | Reflexive (assessment) |
| Extend | Transferring environmental responsibility to STEM projects at local and global levels | Social responsibility |

**3.3. Mechanisms of the Integration in Developing Environmental Responsibility.** Our research revealed that the integration of the 7E model and the STEM approach activates the following mechanisms for developing students' social responsibility toward nature:

First, the cognitive mechanism – by studying environmental problems from the perspective of STEM disciplines (physics, chemistry, biology, mathematics), students gain a deep understanding of their scientific foundations. This, in turn, enables them to realistically assess the scale and consequences of damage to the environment.

Second, the affective mechanism – during the Engage and Explore stages of the 7E model, students' emotional attitude toward environmental problems is shaped. Observing nature, appreciating its beauty and fragility, and participating in projects aimed at preventing its pollution or degradation awaken in students a positive emotional attitude toward nature and a sense of concern for its fate.

Third, the conative mechanism – within the framework of STEM projects, students carry out practical actions to solve environmental problems: they study waste recycling technologies, design energy-saving devices, and undertake greening activities on the school grounds. Practical activity is the most crucial component of social responsibility, developing students' environmental activism and initiative.

Fourth, the reflexive mechanism – at the Evaluate stage, students analyze the results of their activities and their impact on the environment, which in turn develops the ability to make responsible decisions.

**4. Pedagogical Conditions for Developing Students' Social Responsibility Based on the Integrative Model.**

**4.1. The Content of the Concept of Environmental Social Responsibility.** Our research revealed that social responsibility toward nature is a complex personal quality that comprises the following structural components:

1. **Environmental knowledge and understanding** – acquisition of concepts such as ecosystem, interdependence in nature, anthropogenic factors, sustainable development, and others.
2. **Environmental awareness and values** – valuing nature, recognizing its beauty and fragility, and developing a personal stance on environmental issues.
3. **Environmental activity and skills** – the ability to carry out practical actions for nature protection (waste sorting, water conservation, efficient energy use, etc.).
4. **Environmental responsibility and reflection** – the ability to recognize the impact of one's actions on the environment and, on that basis, make responsible decisions.

**4.2. Methodological Recommendations for Implementing the Integrative Model.** When integrating the 7E model and the STEM approach into environmental education, it is advisable to follow these methodological recommendations:

- **Creating problematic situations:** Each environmental topic should be presented to students as a real-life problem (for example, pollution of a local water body, deterioration of air quality).
- **Ensuring interdisciplinary connectedness:** The environmental problem should be analyzed simultaneously from the perspectives of physics, chemistry, biology, and mathematics.

- **Organizing project-based activity:** Students should carry out STEM projects at various stages of the 7E model (e.g., designing a device to measure air pollution levels, proposing a waste recycling technology).
- **Integration with the local community:** Projects should be aimed at solving local environmental problems, and students' findings should be presented to the local community and put into practice.
- **Developing an assessment system:** When assessing the level of students' environmental responsibility, it is necessary to take into account not only their knowledge but also their activity, initiative, and reflection.

**4.3. Expected Outcomes.** Our research found that the implementation of the proposed integrative model is expected to bring about the following positive changes in students:

- A qualitative transformation of environmental knowledge – knowledge becomes systematic, interdisciplinary, and practice-oriented.
- Formation of a positive emotional attitude and a value-based approach toward environmental problems.
- Development of practical skills and an active life stance for nature protection.
- Acquisition of the ability to make responsible decisions to prevent environmental damage.
- Enhanced social activism and initiative in solving local and global environmental problems.

**Conclusion.**

This study analyzed the theoretical and methodological foundations of developing students' social responsibility toward nature by integrating the 7E teaching model and the STEM approach into environmental education. Based on the research results, the following conclusions were drawn:

1. The 7E teaching model is grounded in the constructivist paradigm of education, and its stages (Elicit, Engage, Explore, Explain, Elaborate, Evaluate, Extend) are highly effective in developing students' environmental knowledge and skills. It has been scientifically proven that applying this model significantly increases students' mastery of environmental topics such as climate change [3].
2. The STEM approach develops students' ability to solve environmental problems through interdisciplinary integration and project-based activity. It has been confirmed in practice that the level of environmental awareness of students who participated in STEM-based projects increased to 95% [6].
3. The 7E model and the STEM approach have a logical compatibility, and their integration enables the comprehensive development of the cognitive, affective, conative, and reflexive components of students' environmental responsibility.
4. When implementing the integrative model in practice, it is advisable to follow methodological recommendations such as creating problematic situations, ensuring interdisciplinary connectedness, organizing project-based activities, integrating with the local community, and improving the assessment system.

The proposed integrative model is recommended as an effective pedagogical tool for shaping students' environmental culture and responsible attitude toward nature. The results of this research have practical significance for improving the content of environmental education in general secondary schools and for enhancing teachers' professional training and methodological skills.

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