Chapter 14

Sustainability and Citizen Science in Early Childhood Education in the 21st Century

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Abstract

This study examines the individual and societal impacts of integrating sustainability and citizen science into early childhood education. While sustainability aims to preserve natural resources and promote social equity, citizen science encourages individuals' active participation in scientific processes. Early childhood is a critical period for fostering environmental awareness and introducing scientific methods. In this context, sustainability and citizen science enable children to develop critical thinking, problem-solving, and social responsibility skills. The first section explores the theoretical foundations of sustainability and citizen science, detailing their environmental, economic, and social dimensions. The second section focuses on sustainability approaches applicable in early childhood, such as nature-based learning, recycling education, and technology-enhanced projects. The third section investigates the integration of citizen science into children's learning processes and its contributions to societal awareness, highlighting examples of projects where children acquire skills like data collection and analysis. The fourth section emphasizes the effectiveness of educational methods, including project-based learning, game-based learning, and storytelling, in fostering these concepts. The final section presents recommendations for expanding

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the role of sustainability and citizen science in education. Key suggestions include restructuring curricula, strengthening teacher training, enhancing family involvement, and integrating technology. The study concludes that instilling these concepts at an early age significantly contributes to individual development and societal sustainability.

1. Introduction

1.1. The Changing Role of Education in the 21st Century

The 21st century is characterized by rapid technological, environmental, economic, and social transformations, which have reshaped the priorities of education. In today's world, it is not enough for individuals to possess academic knowledge; they must also demonstrate environmental awareness, critical thinking skills, and a sense of social responsibility (UNESCO, 2019). Within this context, sustainability and citizen science emerge as two fundamental concepts that respond to these needs.

Sustainability emphasizes the preservation of environmental resources and the achievement of social equity (WCED, 1987), while citizen science encourages individuals to actively contribute to scientific research processes (Bonney et al., 2016a; Yanarateş & Yılmaz, 2022; Yılmaz, 2021a; Yılmaz, 2021b; Yılmaz, 2023). Integrating these concepts into education, especially at an early age, can significantly contribute to raising more conscious and engaged future generations.

1.2. The Relationship Between Sustainability and Education

Sustainability encompasses principles such as the conservation of natural resources, the prevention of environmental degradation, and the promotion of economic development in harmony with social equity (Sterling, 2010a). Education serves as a powerful tool to instill these principles in individuals. Goal 4 of the United Nations Sustainable Development Goals (SDGs), which aims to "ensure inclusive and equitable quality education," emphasizes the integration of sustainability into curricula (UN, 2015).

Education for sustainability equips individuals with the ability to recognize environmental problems, devise solutions, and adopt sustainable living habits. Research indicates that introducing environmental awareness at an early age increases the likelihood of individuals adopting sustainable behaviors in adulthood (Davis, 2015).

1.3. The Importance of Sustainability Education in Early Childhood

The early childhood period is a critical phase in which cognitive, emotional, and social development occurs rapidly. Education during this stage plays a pivotal role in shaping an individual's future behaviors and values (Elliott & Davis, 2018). Early childhood education offers unique opportunities to foster environmental awareness and sustainability consciousness.

Integrating activities such as nature exploration, recycling projects, and eco-friendly practices into early childhood curricula enables children to connect with their environment. For instance, hands-on experiences like planting seeds or observing soil processes help children understand ecological systems and develop empathy toward the environment (Wilson, 2020).

1.4. The Role of Citizen Science in Education

Citizen science is an innovative approach that facilitates public participation in scientific research (Hecker et al., 2018). By encouraging community involvement in data collection and analysis, it makes science more accessible and participatory. Projects focused on environmental monitoring, nature observations, and data collection can nurture children's scientific curiosity while fostering a deeper connection with nature (Bonney et al., 2016b; Öztürk & Demiroğlu Çiçek, 2024).

Implementing citizen science projects in early childhood education enhances children's engagement in scientific processes and improves their understanding of environmental challenges. Activities such as birdwatching in a local park or monitoring air pollution levels can help children develop both scientific skills and environmental responsibility (Cochrane et al., 2017).

1.5. The Role of Technology in 21st-Century Education

Technology plays a critical role in integrating sustainability and citizen science into education. Child-friendly mobile applications and digital platforms make it easier for young learners to actively participate in environmental processes. For example, applications that allow children to collect and share local environmental data foster both individual and collective problem-solving skills (UNESCO, 2018).

Moreover, technologies such as virtual reality (VR) and augmented reality (AR) enable children to understand environmental processes more effectively. For instance, a virtual forest tour can teach children about

ecosystem functions while simultaneously enhancing their environmental consciousness.

1.6. Research Problem and Rationale

The primary aim of this study is to highlight the significance of sustainability and citizen science in early childhood education in the 21st century. It explores how environmental awareness and scientific thinking skills acquired at an early age influence lifelong behaviors. Additionally, the study discusses how citizen science can be integrated into children's learning processes and aligned with sustainability goals.

2. Sustainability Approaches in Early Childhood Education

2.1. The Importance of Sustainability Education in Early Childhood

Early childhood represents a critical period during which children develop awareness about their environment and begin forming their value systems. Introducing sustainability education at this stage plays a significant role in fostering environmental awareness, social responsibility, and resource consciousness (Davis, 2015). During this process, teaching children about environmental challenges and possible solutions contributes to raising individuals who are more conscious in adulthood (Elliott & Davis, 2018).

Sustainability education for children is not merely about transferring knowledge; it also allows them to develop skills such as problem-solving, creativity, and empathy through hands-on activities (Öztürk, 2023; Tilbury, 2011). This type of education enhances children's connection with the environment while empowering them to propose local solutions to global challenges.

2.2. Core Principles of Sustainability Education

The success of sustainability education relies on addressing its three primary dimensions holistically: environmental, economic, and social sustainability (Sterling, 2010a).

1. **Environmental Sustainability:** Focuses on preserving natural resources and promoting eco-friendly practices. For preschool-aged children, this approach enables understanding of concepts such as pollution, recycling, and ecosystem cycles.

2. **Economic Sustainability:** Involves efficient use of resources, waste prevention, and fostering economic awareness. Practices like conserving energy or water can fall under this category.
3. **Social Sustainability:** Emphasizes social justice, cultural diversity, and community engagement. Encouraging children to participate in community activities, develop empathy, and learn teamwork are central goals.

2.3. Nature-Based Learning Approaches

Nature-based learning promotes children's participation in educational processes within natural environments. Research shows that interacting with nature improves children's emotional well-being, enhances their attention spans, and develops problem-solving skills (Chawla, 2015). This type of learning not only increases children's knowledge of environmental issues but also strengthens their connection to the natural world.

Examples of nature-based learning activities include:

- **Playing with Soil:** Interacting with soil and plants teaches children the importance of ecosystems.
- **Observing Animals:** Studying animals in their natural habitats helps children understand biodiversity and habitats.
- **Nature Walks:** Enable children to explore and observe environmental processes.

2.4. Recycling and Waste Management Education

Recycling is an indispensable part of sustainability education. Teaching children about waste segregation and the importance of recycling can enhance their contributions to the environment (Tilbury, 2011). Hands-on recycling projects in preschool classrooms effectively support children's learning processes in an engaging way.

For instance, placing bins for plastic, paper, and glass in the classroom can help children understand the recycling process. Such activities also foster problem-solving skills and a sense of responsibility toward the environment.

2.5. Energy and Water Conservation Education

Energy and water conservation are other crucial dimensions of sustainability education. Helping children understand that energy resources are limited and teaching them to use these resources efficiently is vital for

long-term environmental impact (Wilson, 2020). Activities such as energy conservation games or storytelling about water usage can effectively teach these concepts to children.

2.6. Examples of Sustainability Projects

Some exemplary projects that can be integrated into early childhood education curricula include:

- **Gardening Projects:** Children can learn about natural cycles by observing plant growth and caring for them.
- **Nature Journals:** Encourage children to record their daily observations about the environment.
- **Community Participation:** Engaging children in local environmental events fosters their sense of social responsibility.

2.7. The Role of Teachers

The success of sustainability education is closely linked to teachers' knowledge and pedagogical approaches. Teachers should serve as role models to foster positive attitudes toward nature and the environment among children. Actively participating in environmental projects can motivate children and enrich the learning process (Küçük-Demir, 2023).

2.8. Family Involvement

Families play a crucial role in effectively implementing sustainability education. At-home practices such as recycling projects or adopting energy-saving habits help reinforce children's learning (Davis, 2015). Actively involving families in the process enables children to internalize sustainability concepts more effectively.

3. Integration of Citizen Science into Early Childhood Education

3.1. Definition and Scope of Citizen Science

Citizen science refers to an approach that encourages individuals to engage in scientific processes, aiming to make science accessible and understandable to all members of society (Haklay, 2015; Yılmaz & Salman, 2022; Yılmaz, Şahin-Atılgan & Güzel-Sekecek, 2024). This process includes observing the environment, collecting data, and contributing to scientific analyses. Integrating citizen science into early childhood education offers an opportunity to introduce children to scientific processes and develop their

sensitivity toward environmental challenges at an early age (Bonney et al., 2016b).

3.2. The Role of Citizen Science in Education

Citizen science not only teaches children the basic steps of scientific methods but also enhances their societal awareness (Ayyıldız & Yılmaz, 2021; Ayyıldız, Yılmaz & Baltacı, 2021; Elliott & Davis, 2018). Implementing citizen science projects in early childhood education enables children to develop skills in scientific observation, data collection, and analysis. For instance, observing and recording bird species in a park helps children understand environmental issues while fostering their scientific curiosity (Gray et al., 2012; Sevgi & Yılmaz, 2023).

3.3. Applications of Citizen Science Projects for Young Children

1. **Local Environmental Monitoring Projects:** Children can observe and record air, water, or soil pollution in their surroundings using simple methods. These projects enhance children's awareness of environmental issues while encouraging their participation in scientific processes (Shirk et al., 2012).
2. **Nature Observation Journals:** Documenting daily observations of natural changes, such as seasonal transitions or plant growth, helps children improve their observational skills.
3. **Tracking Animal Species:** Counting local animal species and observing their behaviors may foster children's understanding of biodiversity.

3.4. Technology in Citizen Science

Technological tools play a crucial role in the implementation of citizen science. Child-friendly mobile applications, digital maps, and simple data analysis tools allow children to actively engage in scientific processes (Cochrane et al., 2017). For instance, identifying plant species via a mobile app or measuring air pollution in a specific area enables children to participate more effectively in scientific activities.

3.5. Cognitive and Social Contributions of Citizen Science

Citizen science projects contribute to children's development of scientific thinking and social responsibility (Dickinson et al., 2012). Collaborating with community members to address local environmental challenges strengthens children's empathy and sense of societal responsibility.

3.6. Role of Educators

Teachers play a guiding role in the implementation of citizen science. Their knowledge of scientific processes and ability to convey this knowledge to children are critical for the success of such projects (Trumbull et al., 2000). Additionally, educators' attitudes toward environmental issues and their enthusiasm significantly influence children's interest in these projects.

3.7. Parental Involvement

Parental involvement in citizen science projects enhances the benefits children derive from these activities. Parents engaging in nature observations with their children or supporting projects increase children's motivation to learn (Ballard et al., 2017). This process also provides an opportunity for quality family time.

3.8. Community and Citizen Science

Citizen science impacts not only individuals but also communities. Children's participation in local environmental projects develops their ability to address community issues and grow as informed and responsible citizens.

4. Educational Methods Supporting Sustainability and Citizen Science

Integrating sustainability and citizen science concepts into early childhood education requires not only curriculum development but also innovative teaching methods and pedagogical practices (Sterling, 2010b). Effective teaching strategies are essential for fostering children's environmental awareness, participation in scientific processes, and sense of social responsibility (Davis & Elliott, 2014; Sevgi, Ayyıldız & Yılmaz, 2023). This section provides a detailed exploration of educational methods that support sustainability and citizen science.

4.1. Project-Based Learning (PBL)

Project-based learning (PBL) allows students to acquire knowledge and skills by engaging in real-life scenarios centered on a problem or project. PBL is highly suitable for integrating sustainability and citizen science, as children work in teams, observe, and collect data to address environmental issues (Thomas, 2000).

Example Application:

- **Nature Conservation Project:** Children participate in activities such as tree planting, plant observation, or waste collection in a local park, fostering both a connection to nature and problem-solving skills.

PBL is an effective tool for developing critical thinking, problem-solving, and collaboration skills at an early age.

4.2. Game-Based Learning

In early childhood, play is a fundamental way of learning. Game-based learning simplifies abstract concepts like sustainability and citizen science for children (Fisher et al., 2011). Digital games, in particular, are a powerful medium for raising environmental awareness.

Example Application:

- **"Zero Waste Game":** A game designed to teach children about recycling and waste management, either digitally or physically.
- **Nature-Themed Role-Playing Games:** Simulating an ecosystem to help children understand animal life cycles.

Game-based learning engages children actively, making the learning process both enjoyable and effective.

4.3. Storytelling and Visual Learning

Stories are a powerful tool to help children understand complex concepts. Storytelling about sustainability and citizen science fosters empathy and emotional connections with the environment (Wright & Pullen, 2013; Yılmaz, Uysal & Nacar, 2024).

Example Application:

- **"Heroes of Nature" Storybook:** Designing a storybook or visual material to teach eco-friendly behaviors to children.
- **Animations and Short Films:** Addressing topics like pollution, recycling, or biodiversity through visual content.

Storytelling and visual learning methods make children more emotionally and cognitively sensitive to environmental issues.

4.4. Experiential Learning

Experiential learning enables children to acquire knowledge through direct experiences. It is an effective way for children to observe natural

environments, solve problems, and explore their learning processes (Kolb, 1984).

Example Application:

- **On-Site Observation Activities:** Visiting an ecosystem to study living organisms in their natural habitats.
- **Gardening Activities:** Teaching children about basic ecosystem components like water, sunlight, and soil by growing plants.

Experiential learning enhances children's interaction with the environment and develops their analytical thinking skills.

4.5. Technology-Enhanced Learning

Technology serves as a crucial tool in integrating sustainability and citizen science into education. Digital platforms, mobile applications, and augmented reality (AR) technologies enhance children's participation in scientific processes (Hughes, 2005; Yılmaz, Gülgün, Çetinkaya & Doğanay, 2018).

Example Application:

- **"Nature Observation Apps":** Allowing children to identify plant species and digitally record their observations.
- **Virtual Reality (VR) Tours:** Enabling children to explore forests or coral reefs virtually.

Technology-enhanced learning strengthens children's scientific thinking skills and helps them better understand sustainability concepts.

Integrating sustainability and citizen science concepts into early childhood education is achievable through effective teaching methods. From project-based learning to technology-enhanced approaches, these strategies enable children to develop environmental awareness and scientific skills. These methods contribute not only to individual growth but also to societal progress.

5. Conclusion and Recommendations

5.1. Conclusion

This study has highlighted the importance of integrating sustainability and citizen science concepts into early childhood education. In a world increasingly affected by environmental and social crises, these concepts play a crucial role in fostering children's environmental awareness, scientific

thinking skills, and social responsibility (Barron et al., 2015). Acquiring these skills at an early age helps individuals exhibit lifelong eco-friendly behaviors and contribute more effectively to society (Tilbury, 2011).

Technological advancements have further enhanced this process. Tools such as mobile applications, augmented reality (AR), and virtual reality (VR) enable children to learn about environmental data more effectively and participate actively in scientific processes (Bonney et al., 2016c). However, to ensure the success of this integration, educational policies, curricula, and teacher training programs must be aligned to support these concepts.

5.2. Recommendations

1. **Developing Educational Policies**
    - Comprehensive policy frameworks should be established to better integrate sustainability and citizen science into education systems (UNESCO, 2017).
    - Environmental education and citizen science-focused curricula should be widely implemented in early childhood education programs.
2. **Revising Curricula**
    - Activities that help children understand environmental issues and develop solutions should be incorporated into the curriculum. These activities may include nature observations, recycling projects, and sustainable living practices (Davis, 2015).
    - Greater emphasis should be placed on game-based and experiential learning methods in the curriculum.
3. **Investing in Teacher Training**
    - In-service training programs for teachers on sustainability and citizen science should be organized.
    - Training programs aimed at enhancing educators' digital skills should be developed to enable more effective use of technology in the classroom (Elliott & Davis, 2018).
4. **Engaging Families in the Process**
    - Sustainability and environmental education programs should be organized for families, encouraging parents to conduct hands-on projects with their children.

- Parents should be actively involved in school activities related to sustainability and citizen science.

5. **Leveraging Technology and Digital Tools**
   - Mobile applications and games should be developed to help children learn and analyze environmental data (Yılmaz, 2023; Yılmaz, 2024)
   - Virtual ecosystem simulations supported by VR and AR technologies can enable children to establish a more meaningful connection with the environment (Hecker et al., 2018).
6. **Raising Community Awareness**
   - Collaborations among local governments, NGOs, and schools should be encouraged to initiate environmental awareness projects.
   - Community events for children should promote social responsibility and environmental consciousness (Sterling, 2010a).

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