Chapter 10

Innovative Out-of-School Learning Environments in Early Childhood: Digitally Supported Discovery and Experience-Based Approaches

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Abstract

This study investigates the use of digitally supported and nature-based activities in out-of-school learning environments to enhance the impact of STEM education in early childhood. Digital technologies such as augmented reality (AR) and virtual reality (VR) increase children's interest in STEM fields and develop their scientific observation and problem-solving skills. Through these technologies, children can experience abstract concepts in a more concrete way, fostering positive attitudes toward STEM fields. Out-of-school learning environments like museums, science centers, and science festivals enable children to engage with science in a direct and interactive manner. These environments strengthen children's scientific attitudes and curiosity while supporting creative thinking, observation, and social skills. Science festivals, in particular, allow children to interact directly with scientists and experience the scientific process firsthand, thereby fostering an interest in STEM. Science festivals and similar activities provide opportunities to relate STEM concepts to daily life, increasing children's future interest in STEM

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and motivating them to pursue careers in these fields. In conclusion, digitally supported and nature-based STEM applications in out-of-school learning environments stand out as powerful tools for developing children's scientific thinking, problem-solving, and social skills. These activities strengthen children's connection to science, provide a more lasting understanding of STEM subjects, and foster a positive perspective toward STEM in their future educational and career choices.

1.Introduction

Today, rapidly developing technology and scientific advances have made it imperative for students to acquire 21st century skills. Science, Technology, Engineering and Mathematics (STEM) education stands out as an important tool in developing these skills. However, classroom learning environments alone may be insufficient to support the multidimensional knowledge and skill development required by STEM. In this case, out-of-school learning environments (OLE) can contribute to children's learning. OLEs such as museum visits, nature camps, and science centers increase students' interest in science by enabling them to associate abstract STEM concepts with real life experiences (Çevik & Bakioğlu, 2024).

CFLs provide students with the opportunity to relate the knowledge they acquire at school to daily life and explore STEM concepts in the real world. While these learning environments develop students' skills such as creative thinking and problem solving, they also contribute positively to their interest in science. Various studies have shown that OST-based STEM activities help students explore their interest in STEM fields and career options in these fields. In a study conducted by Baran et al. (2019), it was determined that STEM activities in CFLs positively affected students' attitudes towards STEM. CFLs can also be effective in increasing students' interest in professions related to STEM fields. In particular, it has been shown that students who participate in STEM activities in FLCs during middle school are more likely to pursue a career in STEM fields at university (Dabney et al., 2012). Afterschool Alliance (2011) and other studies suggest that FLCs increase students' interest in STEM careers, encouraging them to consider a potential future in STEM fields. Such activities enable students to encounter real-world problems, while at the same time helping them to see more clearly the connections of STEM to everyday life (Bell et al., 2009).

One of the main aims of STEM education is to provide students with 21st century skills such as problem solving, collaboration and critical thinking. Çevik and Bakioğlu (2024) state that STEM activities based on CFL improve students' analytical thinking, problem solving and teamwork skills. Thanks

to its interdisciplinary nature, STEM education can be implemented more effectively in CFLs and students gain scientific thinking skills (Afterschool Alliance, 2011; Krishnamurthi et al., 2014). FLCs such as museum trips or nature camps provide students with direct experience and help them develop a lasting sense of curiosity about STEM subjects.

Another important advantage of FLCs is that they can appeal to different learning styles by offering a flexible learning environment. Students have the opportunity to reinforce their knowledge and gain practical experiences by participating in STEM activities in various FLCs according to their own interests. Panizzon and Gordon (2003) and Smith (2017) emphasize that CFLs are effective in providing students with individual and social skills. The freedom and flexibility offered by these learning environments support students to develop a lasting interest in STEM and encourage them to think in STEM fields on their career path (Mohr-Schroeder et al., 2014).

In this study, the process of creating and implementing the content of digitally supported applications, nature-based activities, and museum and science center experiences to support children's development in out-of-school learning environments in early childhood will be discussed.

2. Digitally Assisted Exploration and STEM Experiences

Digitally supported exploration applications are becoming increasingly widespread today. These applications enable children to digitally experience environments that they cannot physically be in through AR and VR technologies (Hsu et al., 2017). For example, children can explore a virtual version of a forest or an ocean and get to know animals and plant species closely. Such technologies offer children the opportunity to learn about environmental awareness and biodiversity while interacting with nature (Soberanes-Martín, 2022). They can also be used as a virtual preparation stage before real-world explorations. The benefits of AR and VR applications can be listed as follows (Wang et al., 2024; Arjit, 2021):

- **Increasing Interest in Learning**: Increases children's interest in STEM subjects with visual and interactive structures.
- **Active and Child-Centered Learning**: Supports children to learn through independent exploration, making knowledge more permanent.
- **Problem Solving Skills**: Teaches children how to cope with challenges and think critically.

- **Digital Literacy**: Increases children's familiarity with technology and develops their digital skills.
- **Interactive Learning**: Makes learning more inclusive and engaging through multi-sensory experiences.
- **Social Skills**: Strengthens cooperation, communication and social skills through group work.

Below is a VR-based STEM activity.

Journey to the World of Dinosaurs

Age Group 5-6 years old **Event Duration**: 35 minutes

<table>
<tr>
<td>Achievements:
☐ Children recognize dinosaurs that lived in prehistoric times.
☐ Makes scientific discovery using VR technology.
☐ Create a dinosaur habitat using engineering skills.
☐ Develop basic mathematical thinking skills about the size of dinosaurs.</td>
<td>Materials:
☐ VR glasses
☐ Flashcards about the size of different dinosaurs
☐ Cubes or lego pieces (for children to create the dinosaur height)
☐ Dinosaur and natural habitat posters, picture cards
☐ "Dinosaur World Map" drawing papers and crayons</td>
</tr>
<tr>
<td colspan="2">Entrance (5 minutes):
o Give children a brief introduction about dinosaurs. Explain that dinosaurs come in different sizes and shapes and live in different environments.
o Explain how STEM-based learning will help them explore the world of dinosaurs.</td>
</tr>
<tr>
<td colspan="2">Main Activity: STEM Experience (25 minutes)
In this section, cover the content for the four pillars of the STEM approach.</td>
</tr>
<tr>
<td>Science:
o Offer children the opportunity to explore the world of prehistoric dinosaurs using VR goggles.
o Children are introduced to natural sciences by observing dinosaur habitats, vegetation and climatic conditions. For example: "In which environment does this dinosaur live?" and ask them to make observations.</td>
<td>Technology:
o Guide children in putting on and using VR glasses. Simply explain how VR technology works, how to create experiences that seem real in a virtual environment. Emphasize how useful the technology is for scientific discovery and learning.</td>
</tr>
</table>

Engineering:	**Mathematics**:
o After the VR experience, encourage children to think like an engineer. Ask them to imagine and make small models of the habitats where the dinosaurs they saw lived (e.g. a forest, a swamp or a mountain). o Ask them to create a dinosaur habitat with materials such as Lego or cubes. Encourage them to make their own creative designs by asking them questions such as "In what environment did this dinosaur live and what kind of shelter or environment did it need?".	o Give children cards to compare the size of different dinosaurs. For example, explain that the size of a T-Rex is about the length of 4 children. o Ask the children to estimate the size of a particular dinosaur by stacking Legos or cubes on top of each other. Thus, children gain the ability to measure and compare objects.
Evaluation (10 minutes): o Observe the habitats the children created and the measurements they made. Observe how they understand the STEM activity by having each child share their experiences. o Ask children questions about the world of dinosaurs they discovered with VR and the habitat they designed. o End the activity by asking what the children learned from their STEM experiences. o Ask each child to draw or color something about the dinosaurs they saw at the end of the activity.	

When the activity is examined, it is seen that a structure that allows preschool students to handle different skills together and interactively with technology is presented. VR technologies will be especially useful in presenting areas such as living things, plants and places that are impossible to see today.

3. Nature-Based STEM Activities and Science Teaching

Nature-based STEM practices offer many benefits to children in preschool education. These practices enable children to develop an interest in nature and science by exploring their environment. In particular, digital tools such as augmented reality (AR) and tablet technologies enable children to experience natural phenomena and STEM concepts in a more concrete way, contributing to the development of scientific thinking and problem-solving skills (Bagiati & Evangelou, 2016; Kastriti et al., 2022).

Digital technologies such as augmented reality and virtual reality allow individuals to concretize subjects. Thanks to these applications, children can observe natural phenomena (such as the water cycle or plant life cycle) in a

virtual environment and experience these processes in a more concrete way. In this way, digitally supported nature-based STEM activities will support children's imagination and help them develop digital literacy at an early age. Children also develop their social skills by using such technologies, as these applications will encourage collaboration, often requiring group work (Larkin & Lowrie, 2019).

These activities will ensure children's active participation and encourage them to make discoveries in science, technology, engineering and mathematics. This will help children develop STEM skills in a natural learning environment and prepare them for future learning processes (Kastriti et al., 2022). The characteristics of such activities can be as follows.

1. **Focus on Direct Exploration and Experience**: It should allow children to directly experience science through observation in the natural environment.
2. **Help to Concretize**: Make abstract science concepts understandable by making them concrete with various materials (e.g., simulating the water cycle with water containers and leaves).
3. **Supported by Digital Technologies**: Using tools such as augmented reality (AR) and tablet applications, processes in nature should be observed in a more detailed and engaging way.
4. **Promote Social Interaction and Cooperation**: Group work should strengthen cooperation skills and enable children to learn socially.
5. **It should stimulate curiosity and encourage questioning**: Children should be encouraged to observe and ask questions such as "Why?" and "How?".
6. **Promote Sustainability and Environmental Awareness**: Include activities that instill environmental awareness and a love of nature (e.g. recycling projects or growing plants).
7. **Use Natural Materials and Environments**: Activities that enrich children's sensory experiences should be carried out with natural materials such as soil, water and leaves.
8. **Help them understand the scientific process**: Include steps of the scientific method such as observation, hypothesizing, experimenting and drawing conclusions.

In this context, the following lesson plan is presented:

Discover the Mysteries of Nature: Navigation and Exploration Mission with AR

Age Group: 5-6 years (preschool) **Event Duration**: 40-50 minutes

Achievements:	**Materials**:
☐ Children develop orientation and exploration skills in nature. ☐ Their ability for scientific observation and recognition of the environment increases. ☐ Gain digital literacy using AR technology. ☐ Develops awareness of nature and observation skills.	☐ Tablet or smartphone (with augmented reality (AR) app installed for the exploration mission) ☐ Exploration mission map or mission cards with clues ☐ Small notebook or drawing paper and crayons ☐ Magnifier
Preparation for a Discovery Mission in Nature (10 minutes): ☐ Excitement is aroused by telling the children that they are going on a special exploration mission in nature. They are told that there are clues hidden in nature such as "mysterious plants" and "animal tracks" that they need to discover. ☐ Children are given task maps or task cards and it is explained that they will explore certain points in nature by seeing them. ☐ Children are told that AR technology will help them see these mysterious places and show them the "unseen secrets" of nature.	
Exploration Mission with AR: Finding Mystery Spots and Clues (10 minutes): ☐ Children take turns guiding the tablet or phone to specific points and discover hidden clues with the AR app. For example, a type of mushroom may appear next to a tree or an anthill may appear on the ground. ☐ When children see plants, insects or animal tracks with AR, you can ask them about them and ask them questions to share their observations. For example: "Have you seen this plant before? Which animal do you think this trace belongs to?" ☐ The children are asked to draw these "mysterious" plants or animal tracks in their notebooks or on drawing paper.	
Exploration and Investigation in Nature (10 minutes): ☐ Continue exploring the mystery spots with the children and use the magnifying glass to find similar plants or animal tracks in the real world. ☐ They are guided to closely examine these objects in nature. Help them recognize the similarities between the digital elements they see with AR and real objects in nature.	
Creating and Sharing an Exploration Journal (10 minutes): ☐ Children are asked to record what they find and learn in their "Discovery Diary". Each of them can express their clues and observations with drawings or short explanations. ☐ In the journal, they are asked to write and illustrate what they think about animal tracks, plants or hidden "treasures" they encounter in nature. ☐ They are encouraged to share with other children what they have learned during the discovery process and what interests them the most.	

Evaluation (10 minutes):
- ☐ How children express their observations and follow the clues throughout the exploration task can be assessed.
- ☐ It can be observed how effectively they complete the discovery task by linking AR and nature observations.

This activity enables children to make both a physical and digital exploration in nature. It supports their learning process by interacting with AR technology in nature while developing orientation, observation and environmental recognition skills. This task allows children to use digital technology creatively in nature while increasing their sense of curiosity about the natural world. AR applications such as Seek by iNaturalist, PlantSnap and Arloon Plants can be used in this activity.

4. Innovative Museum, Science Festivals and Science Center Experiences

Innovative museums, science centers and science festivals stand out as powerful tools for promoting STEM in preschool education. Such learning environments provide children with a natural connection to scientific concepts, stimulate interest in science, technology, engineering and mathematics (STEM) subjects and develop their discovery skills.

4.1. Museums and Science Centers: Museums and science centers are ideal for children to develop scientific discovery and observation skills. Abacı and Usbaş (2010) argue that museums contribute to children's social-emotional and cognitive development and that museum visits add diversity to the educational process and offer different learning environments. In this context, in line with Hein's constructivist approach, Tallou (2022) stated that museum activities, in which children learn through direct experience, increase interest in science, especially in the early age group within the framework of multiple intelligences theory. Unlike the traditional classroom environment, the information that children learn by observing in museums provides a multi-sensory experience and encourages children to participate more actively in the scientific thinking process. The main characteristics of innovative museums can be listed as follows.

☐ **Interactive and Participatory Experiences**: Innovative museums encourage visitors to actively participate in exhibitions rather than just watching them. Digital technologies such as touchscreens, motion sensors, augmented reality (AR) and virtual reality (VR) can be used to participate in exhibitions. In this way, visitors can learn by living and experiencing the information instead of just watching it.

- **Education-Focused and Age-Adapted Content**: Innovative museums offer educational content that appeals to all age groups, engaging visitors from children to adults. While fun activities such as science experiments, games and creative workshops are organized for children, interactive content that provides more in-depth information can be offered for adults.
- **Online and Digital Access Opportunities**: With digitalization, innovative museums offer online exhibitions and virtual tours, enabling access without being tied to a location. Visitors can view exhibitions, participate in online workshops and explore museum content at their own pace through the museum's digital platforms.
- **Environmental and Social Awareness**: Innovative museums are effective in raising visitor awareness about environmental issues, sustainability and social responsibility. For example, interactive exhibitions on issues such as climate change, water conservation or biodiversity can raise awareness among visitors.
- **Highlighting the Connection between Art and Science**: Innovative museums can showcase the interactions between science, art, and technology, enabling visitors to see information from different fields together. In addition to STEM (Science, Technology, Engineering, Mathematics) based education, such museums also support STEAM (Art) integration. Thus, by combining science and art, they provide multifaceted learning experiences.

There are many innovative museums in Turkey that offer engaging experiences of science and technology. Among these, the Istanbul Museum of Illusions offers an environment that captures the attention of visitors through optical illusions, perceptual illusions and interactive experiences. The museum makes scientific concepts more fun and understandable through various interactive exhibits such as light, shadow and perspective games. These features especially help children to develop their perception and observation skills.

Another important innovative museum, Konya Science Center is Turkey's first TUBITAK-supported science center. The center has interactive exhibition areas in many different fields of science such as astronomy, physics, biology and robotics. Enriched with VR and AR technologies, these exhibitions help visitors learn scientific concepts in a more concrete and impressive way. In addition, the observatory at the center offers children and young people a practical learning environment in astronomy.

Istanbul Rahmi M. Koç Museum is an important museum that sheds light on Turkey's industrial, transportation and communication history. Exhibiting a wide collection of historical steam engines, classic vehicles, airplanes and submarines, the museum provides a very impressive environment for those who want to explore the historical development of technology. It also offers an educational experience on science and technology with various workshops and interactive areas for children.

IBB Kültür AŞ Digital Experience Museum in Istanbul is a digital art and science-themed museum that uses virtual reality (VR) and augmented reality (AR) technologies to provide visitors with an interactive experience. Applications such as space travel with VR glasses or exploring nature in a virtual environment make science fun and immersive. Exhibitions enriched with digital technologies enable visitors to understand scientific topics with a modern approach.

Kayseri Science Center is another science center supported by TÜBİTAK and has exhibition areas covering many scientific fields such as robotics, space, natural sciences and human anatomy. VR-supported activities and hands-on science activities, especially for children, are designed to increase young visitors' interest in science. Kayseri Science Center makes learning more fun by offering children the opportunity to make scientific discoveries.

Finally, Eskişehir Science Experiment Center and Sabancı Space House have specially designed areas for children interested in science and astronomy. Various experiments at the Science Experiment Center help children better understand scientific concepts, while the Sabancı Space House provides astronomy education and helps them learn about space and planets. Observation activities supported by VR technology allow children to meet science in a more interactive way.

These museums offer a variety of learning opportunities to raise awareness of science and technology in Turkey and inspire children in STEM. Attracting the interest of both children and adults, these museums support scientific education in Turkey with innovative approaches that bring science together with society.

4.2. Science Festivals: Science festivals increase children's interest in science as events where STEM topics are presented in a fun and accessible way. Organizations such as the TUBITAK 4007 Science Festival support program in Turkey play a critical role in developing scientific attitudes as they provide children with the opportunity to meet scientists while introducing them to scientific processes (Başaran & Karakoç Topal, 2022). Robotics

and experimental learning activities offered at these festivals contribute to children's positive attitudes towards scientific knowledge by increasing their interaction with STEM. Ates et al. (2021) also stated that science festivals are effective in introducing scientists as accessible people who are related to daily life by shaping participants' perceptions of scientists. These activities trigger children's curiosity about science by providing both a fun and educational environment for them. As emphasized in Jensen and Buckley's (2012) study, through these festivals, children have direct contact with scientists, learn about scientific research, and have the opportunity to make their own discoveries. However, Kennedy et al. (2018) pointed out that such events tend to attract individuals who are already interested in science and that more inclusive strategies are needed and that structural changes are necessary for science festivals to reach wider audiences.

Science festivals are useful in showing children and young people the fun and hands-on side of science. Activities such as experiment workshops, robotics, augmented reality (AR) and virtual reality (VR) experiences allow participants to explore science first-hand. Such activities help children and young people develop scientific thinking skills and learn basic scientific processes such as critical thinking, observation, and hypothesis formulation.

Another important contribution of science festivals is that they raise scientific awareness in society. These events show the importance of science and the necessity of scientific thinking to different segments of society. At the same time, they allow participants to communicate directly with scientists, thus developing a more informed perspective on the role of scientists in society.

Science festivals held in various provinces in Turkey within the framework of the TÜBİTAK 4007 Science Festivals program aim to arouse interest in science all over the country. These festivals, organized under the 4007 Science Festivals Support Program, are held all over Turkey with the aim of generating interest in science and technology and promoting the culture of scientific thinking. TÜBİTAK supports these festivals in cooperation with various municipalities, universities, schools, science centers and non-governmental organizations, thus reaching a wide segment of the society. TÜBİTAK 4007 Science Festivals Support Program was launched in 2015. This program aims to disseminate science culture and communication to wider segments of the society, to deliver scientific knowledge to the participants and to understand the interaction between science-technology-society through events.

The activities to be organized at science festivals should be designed to attract children's interest and offer a fun experience as well as being educational. Below is an activity that can be implemented in science festivals:

Finger Rockets: Launching Our Own Rocket!

Age Group: 4-6 years (pre-school) **Activity Duration**: 30-40 minutes

Achievements:	**Materials**:
☐ Children build a simple launch system and experience the concept of air pressure. ☐ Develops observation, prediction and inference skills. ☐ Fine motor skills and hand-eye coordination are strengthened. ☐ Problem solving and creative thinking skills develop.	☐ Paper (cut to size for finger rocket) ☐ Scissors ☐ Adhesive or tape ☐ Colored pencils or paints (to decorate the rocket) ☐ Plastic pipette (thin pipette and a thicker pipette)
Introduction and Rocket Introduction (5 minutes): ☐ Children are introduced to the activity by saying "Today we are going to make our own little rockets and launch them!". Draw their attention by giving simple explanations such as how rockets fly and why they need pressure for launching. ☐ Explain to the children that finger rockets are made of paper and that they will be launched with a straw.	
Finger Rocket Making (10 minutes): ☐ Each child is given paper and straws prepared for finger rockets. Children are asked to shape the paper into a small rocket. They are shown that they should roll the body of the rocket to fit the straw and secure it with tape or glue. ☐ Explain that they should close the tip of their rocket so that no air can escape during launch. ☐ Children decorate their rockets with colored pencils or paints.	
Rocket Launch (5-10 minutes): ☐ Children are asked to place the thin straw inside the rocket body. Then, they are asked to launch their rockets by blowing or gently pressing the thin straw placed inside a thicker straw. ☐ Children are asked to observe how far the rocket goes and share their results. They are allowed to experience how to launch the rocket with different blowing power or angle.	
Conclusions and Observations (5 minutes): ☐ Together with the children, talk about how rockets fly. They are encouraged to make simple observations, trying to understand which rocket goes the farthest, why it moves faster or slower. ☐ The activity is completed with questions such as "Do you know how rockets fly now?" by asking the children to share what they have learned.	
Evaluation (10 minutes): ☐ Children's skills in rocket building, their observations and their ability to draw conclusions can be observed. ☐ The experience of launching rockets at different angles helps them understand simple processes of experimentation and observation.	

This activity will help children understand the concepts of pressure, air and motion by presenting a simple scientific experiment. With its fun and easy-to-implement structure, it supports children's interest in science and creative thinking skills.

5. Conclusion

This study examined how digitally supported and nature-based activities can be implemented in out-of-school learning environments to increase the impact of STEM-based learning processes for preschool children. In particular, digital technologies such as AR and VR have been found to increase children's interest in learning processes and contribute to the development of positive attitudes towards STEM fields (Hsu, Lin, & Yang, 2017; Wang, Abdul Rahman, & Nizam Shaharom, 2024). These technologies help children connect with nature by strengthening their scientific observation and problem-solving skills (Ajit, 2021).

Out-of-school learning environments such as museums, science centers, and science festivals are powerful tools to develop children's interest and motivation towards STEM. Çevik and Bakioğlu (2024) emphasize that these environments develop students' creative thinking and analytical skills, while studies such as Tallou (2022) show that interactive exhibitions in museums increase interest in science. Thanks to such environments, children directly experience scientific processes and associate them with daily life, which reinforces their interest in STEM fields (Abacı & Usbaş, 2010; Bell et al., 2009).

Children's direct interaction with scientists in activities such as science festivals strengthens their scientific attitudes and curiosity and increases their interest in STEM fields (Jensen & Buckley, 2012; Kennedy, Jensen, & Verbeke, 2018). In particular, organizations such as TÜBİTAK-supported science festivals in Turkey enable children to develop a lasting curiosity about STEM-related concepts (Başaran & Karakoç Topal, 2022). In conclusion, digitally supported and nature-based STEM practices in out-of-school learning environments play an important role in developing children's scientific thinking, problem solving and social skills. By providing children with the opportunity to interact with science, these activities provide more lasting learning about STEM concepts and contribute to their development of a positive perspective towards STEM in their future educational and career choices.

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