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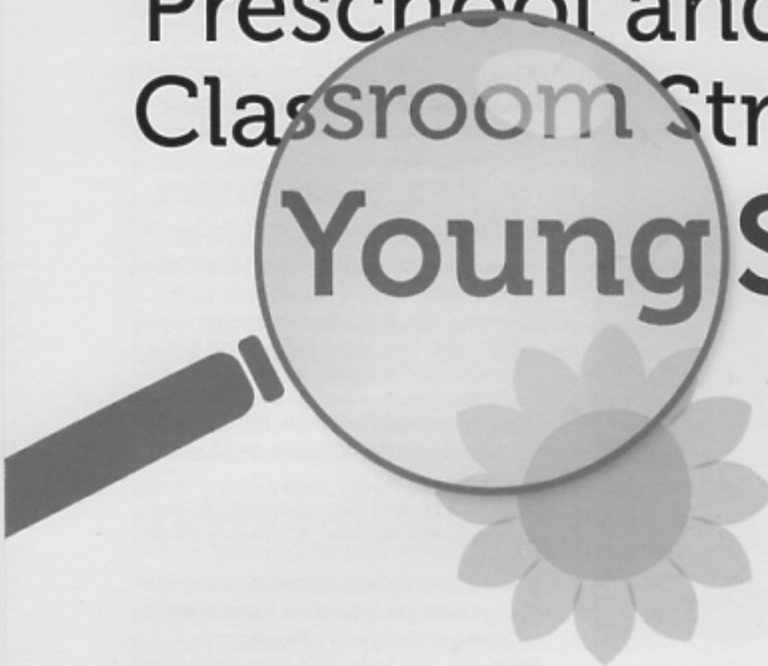
Preschool and Kindergarten Classroom Strategies for the Young Scientist



Ann Gadzikowski

The scientific mind

Children who are exceptionally bright in the area of science are likely very observant, carefully watching all kinds of phenomena in the natural world. They notice how things grow or how our bodies work, and they look under lids or rocks, noting the diversity and intricacy of the world around them. They may demonstrate an intense and focused curiosity about certain things, such as the child who, on a class field trip to a farm, refuses to move away from the incubator, determined to stay and watch every detail of a chick hatching from an egg. Children with scientific minds may be extraordinarily curious about technology and mechanics, observing how things are built, how they work, and how to fix things that are broken.

Throughout history, many great scientists, including Marie Curie and Thomas Edison, have been remembered as demonstrating unusually intense levels of curiosity as young children. Albert Einstein often told the story of his fascination, at just 4 years old, with the workings of a magnetic compass. He felt that there had to be "something behind things, something deeply hidden" (American Institute of Physics 2004). Like Einstein, young children with an unusual aptitude for science are intense and curious observers. In addition to curiosity, some other personality traits you might see in children with an exceptional talent for science include

- Playfulness
- Risk taking
- Originality
- Persistence
- Independence

Braiding the thread

In science, all three strategies for challenging bright children—differentiation, conversation, and connection—are truly woven and bound together. In fact, it's difficult to talk about them as separate strategies because the two examples of best practice discussed in this article—using the scientific method and inquiry-based learning to build on children's interests—require a continuous mix of all three strategies.

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The scientific method

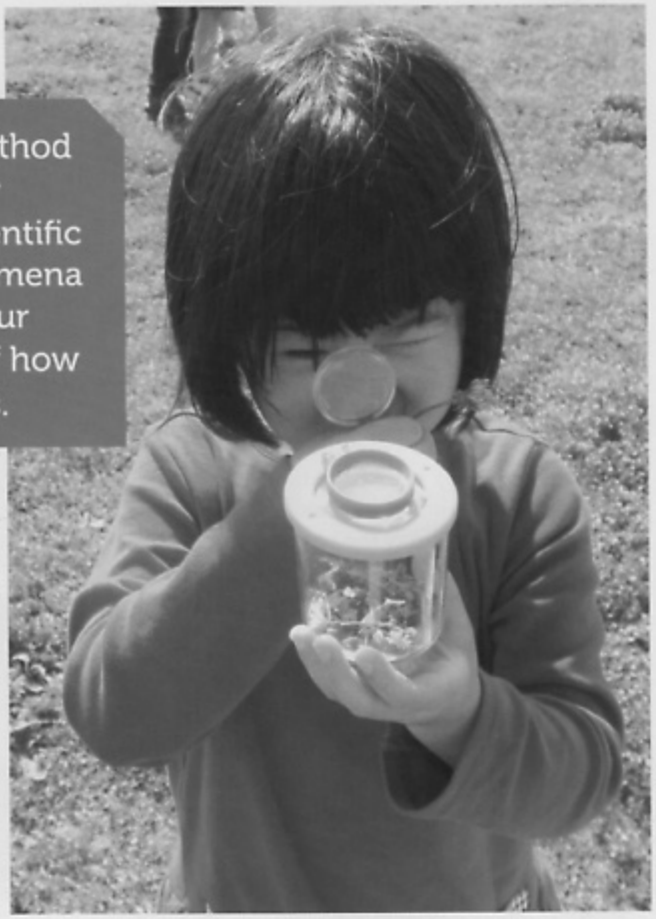
> The scientific method is a technique for investigating scientific or natural phenomena and deepening our understanding of how the world works.

Regardless of what scientific topic captures the interest of the children in your class, you will be best equipped to challenge children who are exceptionally bright if you structure your science-related curriculum using the scientific method. The scientific method is a standardized technique used in the field of science and science education for investigating scientific or natural phenomena and deepening our understanding of how the world works. The scientific method follows a sequence like this:

1. Ask a question.
2. Do preliminary research on the question.
3. Construct a hypothesis, which is a possible explanation as to how or why something occurs.
4. Conduct an experiment or make intentional observations that test the hypothesis or try to show it is wrong.
5. Analyze the data and draw a conclusion.
6. Communicate the results by presenting your findings to others.

It's important to note that if your results in step 5 don't show your hypothesis to be wrong, then you know it could be right. In the scientific realm, if enough experiments are done or observations made, and enough consistent results collected, then scientists conclude that a hypothesis is likely to be correct.

> **This article** is an excerpt adapted from *Challenging Exceptionally Bright Children in Early Childhood Classrooms*, by Ann Gadzikowski. While the focus of the book is on meeting the needs of children with advanced cognitive ability, the primary teacher strategies for doing so—differentiation, conversation, and connection—benefit all children. The following are descriptions of these three strategies.
>
> **Differentiation**—changing the pace, level, or method of teaching to respond to the needs of individual children.
>
> **Conversation**—engaging in discussions with children that challenge them to think deeply and creatively. Teachers can ask questions and provide children with feedback.
>
> **Connection**—helping children learn from each other. Teachers can facilitate this through pairing and grouping children, extending conversations and play, and modeling collaborative learning.



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In a preschool or pre-K classroom, the scientific method might look like this:

1. Ask a question. One day on the playground a child asks, "Why doesn't the grass grow on the sidewalk?" The teacher could respond, "Because cement does not have the same nutrients as soil," or any number of logical, informed explanations. Instead, the teacher uses the question as a starting point for scientific exploration and replies, "That's a good question. I'm going to write it down. 'Why doesn't grass grow on the sidewalk?' Let's find out."

2. Do preliminary research on the question. With the teacher's support and facilitation, the child conducts some research by thinking about and compiling what she knows about seeds, sidewalks, and so on. She may also talk to adults and look at books independently or with the help of an adult. Even picture books can be helpful. She learns that plants need soil, water, and sunshine to grow. She learns that many plants grow in garden soil that is dark brown in color, moist, and soft.

3. Construct a hypothesis. Now that the child has gathered some information, the teacher invites her to come up with her own idea that might answer the original question. The teacher states that the goal is to make a hypothesis and explains that a hypothesis is "a guess based on what we think could be a good explanation." He asks the child, "What's your guess? What is your hypothesis for why the grass does not grow on the sidewalk?" She replies, "Because the sidewalk is hard. The ground has to be soft to grow things." The teacher says, "That's an interesting idea. I'm going to write it down and post it on the wall where everyone can see it and think about it."

4. Conduct an experiment that tests the hypothesis. The teacher helps the child come up with a plan for testing the hypothesis. By this time, many other children in the class have become interested in the process and want to be part of the experiment. The children fill two pots, one with soil and one with a few chunks of hard cement. They sprinkle grass seeds across the top of each filled pot. They set the pots on a sunny windowsill and water the pots every morning. Each day the children draw pictures and take photos of what they see in each pot. On the seventh day, the grass seeds in the soil begin to sprout.

5. Analyze the data and draw a conclusion. The teacher helps the children number all their drawings and photos and display them, in order, on a classroom wall. He invites them to study the data they have collected and draw a conclusion. "Do you think your guess, your hypothesis, was right? Does grass need something soft to grow?" The children decide the answer is probably yes. The hypothesis is likely to be correct.

6. Communicate the results. The teacher helps the children create a mural that demonstrates the entire process, from the question and initial research to the hypothesis to the experiment to the conclusion. Parents are invited to view the mural. The teacher follows up by asking the children, "What other questions do you have that haven't been answered?" One of the children asks, "What makes the sidewalk so hard?" This question will lead to further explorations and discovery.

In addition to curiosity and passive observation, children with an aptitude for scientific thinking have the capacity to draw conclusions and make predictions about what they observe. When teachers use the scientific method to explore ideas and questions, there are multiple opportunities for differentiation, conversation, and connection. For example, differentiation takes place because the scientific method is open-ended enough to allow children who are exceptionally bright to ask even more complex questions than their peers ask, as well as to challenge them to think more deeply about the process, draw conclusions, and make predictions.

> Inquiry-based learning is a learning process that is driven by children's questions.

Drawing conclusions

When we draw conclusions we are using information, facts, or ideas to determine other new information or ideas. A child may notice at the end of lunchtime that the bowl of carrots is still half full but the bowl of strawberries is almost empty and draw the conclusion that "kids like strawberries better than carrots." Sometimes young children, because they still have so much to learn about the world, draw conclusions that are inaccurate. Suppose a child sits on the playground, using his fingers to tear blades of grass into tiny pieces and then looks at the green stains on his hands, exclaiming, "Grass has blood like people, but it's green blood." He has observed the moisture on his fingers, recalled what he knows about blood, and made a connection between the two. He has drawn a conclusion that is not exactly accurate but does use both logic and creativity. Ideally, in a learning community, mistaken conclusions are seen as opportunities for deeper learning. In this example, the conversation could lead to explorations and learning about the similarities and differences between plants and people. The end result of this child's "mistake" is an unusually deep and nuanced understanding of the core concepts of biology before the child even enters kindergarten.

Making predictions

When we make predictions we are using information, facts, or ideas to guess what will come next. Suppose a child sits at the classroom window, ignoring the teacher's repeated requests to clean up the puzzles so the class can go play outside. Exasperated, the teacher asks, "Why aren't you cleaning up?" The child replies, "Because we can't go outside. It's going to start raining soon." The child has been observing the dark clouds collecting on the horizon and he calls upon his previous knowledge of weather to make an informed prediction about what will happen next. In this example, the teacher might use the child's prediction as a starting point for an inquiry-based project related to the weather that involves graphing the child's predictions over time.

Inquiry-based learning

Inquiry-based learning is a learning process that is driven by children's questions. It is not about the need to teach children predetermined concepts or facts. Using children's questions to drive the curriculum, whether by adopting the scientific process or by using other curriculum structures, results in a rich, participatory learning experience that is especially beneficial to children who are exceptionally bright. An inquiry-based approach naturally incorporates all three strategies of differentiation, conversation, and connection.

Both the project approach and the Reggio Emilia approach are examples of an "emergent" curriculum process that is facilitated by teachers but led by children's interests and questions. In both approaches an emergent topic is explored over a period of time, usually by the whole class though often there are subtopics that are explored by small groups within the class. Children ask questions, make predictions, collect data, analyze their findings, and share their conclusions. Documenting learning through dictation, photographs, drawings, and other methods provides information that helps to shape the path of the project, assess children's growth, and stimulates children's reflection and metacognition. Children and teachers may use a variety of media to create documentation and represent what they know. Art materials, both two- and three-dimensional, and other media (for instance, dance) are used to explore what Reggio Emilia educators call "the hundred languages of children." These inquiry-based, emergent approaches are particularly suited for exploring science topics because of the emphasis on open-ended exploration and discovery. The process is so well suited for meeting the needs of children who are exceptionally bright because the group work and documentation process provide natural opportunities for teachers to differentiate for the more advanced learners in the class. Teachers can engage children in challenging conversations about what they are learning and group children in ways that maximize social learning and connection to each other in learning relationships.

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The role of the lead investigator

The processes described in this article are appropriate for all children in any preschool, pre-K, or kindergarten classroom. The beauty of these open-ended projects is that every child can participate at any level of ability or interest. But these projects are especially important for the exceptionally bright children because they allow them to take an idea and run with it. Often the child who is exceptionally bright will be the one to initiate a project, to ask the interesting questions, to light the fire that gets the rest of the class going.

Don't be afraid to develop a special role for a child who has exceptional interest, knowledge, or ability in a specific subject area or topic. One of the common characteristics of exceptionally bright children is that they often develop an intense and sustained interest in a single topic, trains or insects, for instance. When a classroom project is sparked by the special interest of one child, that child can be given the role of "lead investigator."

Creating the role of the lead investigator in a classroom project supports the Vygotskian notion that children thrive when they are learning in a social context. The concept that children learn from each other supports the idea that teachers should organize curriculum projects and group children according to their interests, not abilities. For example, an exceptionally bright child who has a lot of knowledge and passion for the topic of dinosaurs could be encouraged to lead other children in gathering research using picture books, plastic models, and fossil replicas. There will likely be other children in the class who will become just as excited about dinosaurs as the lead investigator, even if their capacity to memorize, organize, and apply the facts is not as advanced as that of the exceptionally bright child. All the children in the research group will benefit from sharing their ideas and enthusiasm with each other.

Engineering and technology

Looking through a catalog of children's books, you might get the impression that science is just about nature and animals. Those are the topics most commonly addressed in an early childhood curriculum. But some children who are exceptionally bright develop a special interest and aptitude for engineering and technology. These are important branches of science as well. A child with an intense curiosity about how things work needs opportunities to take things apart. Finding machines and appliances that can be safely deconstructed can be a challenge. Because computers, televisions, and many electronics contain chemicals

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and other hazardous materials, children should not be allowed to dismantle them.

Machines with very simple components, such as windup clocks or rotary telephones, can be safely taken apart, though children should still be well supervised during the process. Another option is to create a collection of pieces of machines, such as gears, springs, pipes, wire, and levers (taking care to avoid anything sharp or potentially dangerous), that children can use to make their own contraptions. Add some pieces of wood or cardboard for bases and a supply of tape and string to help hold things together and you'll be amazed at what children are able to create.

Technology

Technology is both a tool for teaching science and a subject of science study. The National Science Foundation and other leading groups in science and education use the acronym STEM to refer to four subjects: science, technology, engineering, and math. STEM educators and researchers advocate for the development and expansion of education that integrates all four subjects using innovative and engaging learning experiences. For more information and resources, visit the STEM Education Resource Center at www.pbs.org/teachers/stem.

Technology can be used in an early childhood classroom to support children who are exceptionally bright in their explorations of science and engineering topics. Online tools and resources are available to teachers through sites such as PBS Building Big, found at www.pbs.org/wgbh/buildingbig/index.html. With support from a teacher, interactive web activities designed to teach science to older children, such as the Annenberg Foundation's Amusement Park Physics, can be played by exceptionally bright young children. The website is www.learner.org/interactives/park physics/index.html.

Develop a Panel of Experts

Teaching children who are exceptionally bright can be a humbling experience, because sometimes the children's abilities, skills, and knowledge exceed our own. This can be especially true on topics related to engineering and technology. Don't be afraid to say, "I don't know," when a child asks you a question that pushes beyond your own experience and training. Use this as an opportunity to model a learning process that involves seeking expert advice. Consult with a public librarian about books and other media resources on the topics that interest the children in your class. The faculty at local colleges and universities may also be good resources for specialized information. Local experts in the field of science, engineering, and technology are likely to be pleased and flattered that you would seek them out. Don't be shy about inviting them to visit your classroom. As when any outside visitor is coming, be sure to plan and supervise the event carefully, perhaps coaching the guest ahead of time about how to present information in a developmentally appropriate fashion. An engineering professor might demonstrate a robotic arm and explain how robotic appliances are designed and constructed. Perhaps she could also bring a photo of herself as a young child and share stories of her own childhood experiences that led to a career in engineering.

> One of the important lessons we can teach children is the value of making mistakes.

Encourage mistakes

One of the important lessons we can teach children is the value of making mistakes. Some of the most significant scientific discoveries were made by accident, such as Alexander Fleming's 1928 discovery of penicillin when he accidentally let a strange fungus grow on his culture samples. Exceptionally bright children, who may already have become accustomed to always getting the "right" answer in school, benefit from working with teachers who embrace mistakes as a sign of creative exploration. Who knows? The child making brilliant mistakes in your classroom today could one day invent a medicine or machine or process that will benefit countless people.

Reference

American Institute of Physics. 2004. "A. Einstein: Image and Impact: Formative Years I." www.aip.org/history/einstein/early1.htm.