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Keynote Speaker
Jim Delisle
Professor Emeritus,
Kent State University
President,
Growing Good Kids, Inc.

A former classroom teacher, teacher of gifted children, and counselor of gifted adolescents, Jim Delisle recently retired from Kent State University where he served as Director of undergraduate and graduate programs in gifted child education for 25 years. He is the author of numerous articles and 14 books, including The Gifted Kids Survival Guide: A Teen Handbook, with co-author Judy Galbraith.

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Math & Science

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- OpenCourseWare Resources for Advanced High School Study
- Finding a Mentor for High School Independent Scientific Research
- Cogito.org: Website & Online Community for World’s Most Talented Youth
- Inquiring Minds: Reaching Gifted Students with Challenging Science
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- An exciting resource for gifted high school students
  
  *Steve Carson*

**Cogito.org: A Website and Online Community for the World’s Most Talented Youth**

- A website for students with exceptional abilities in math and science
  
  *Linda E. Brody*

**Singapore Math: Challenging and Relevant Curriculum for the Gifted Learner**

- A math curriculum that gets kids involved
  
  *Melody Hazelton*
  
  *Donna Brearley*

**Finding a Mentor for High School Independent Scientific Research**

- Advice from someone who benefited greatly from a mentor
  
  *Amber Hess*

**How to Maximize Learning for Gifted Math Students**

- An appropriate curriculum is vital
  
  *Scott A. Chamberlin*

**Inquiring Minds: Reaching Gifted Students with Challenging Science**

- Using the inquiry method to teach science
  
  *Fred Estes*
  
  *Lisa Dettloff*

## Columns

**Continental Thoughts: Books and Dreams**

- Getting to the heart of the matter
  
  *Luc Kumps*

**The Affective Side: Meeting the Needs of Gifted Students with Attention Deficit Disorder**

- Understanding what works and doesn’t work with this population
  
  *Jean Strop*

**Book Bag: Rio Grande Stories**

- A unique and appealing book for middle grade and secondary gifted students
  
  *Jerry Flack*
Parents know when their child has a passion, such as math or science, but they often don’t know how to help her pursue that intense interest. Teachers know how to help, but unless the youngster displays his talents on tests or in classroom activities, they may not know that he needs more challenge in those areas.

In *Raising a Gifted Child* (Prufrock, 2009), Carol Fertig describes a young boy who was gifted in math. His school did not have a gifted program, and he found math too easy. His parents “…hated to see him bored with something he loved so much…” (p. 146).

In *Best Practices in Gifted Education*, Ann Robinson, Bruce M. Shore, & Donna L. Enersen (NAGC, 2007) state, “The research in science education suggests that a curriculum based on in-depth understanding of science concepts and ‘new science’ standards that focus on an investigatory rather than the more traditional approach best develops the talents, interests, and motivation to do science in the real world for talented learners” (p. 163).

The authors in this issue of *Understanding Our Gifted* offer a variety of perspectives and practical resources in areas of math and science. These articles include challenge and excitement for the gifted student who needs to move on in an area of interest, as well as curriculum ideas and home activities for teachers and parents.

We value your feedback, opinions, and suggestions. Contact Editor Carol Fertig: cfertig@eathlink.net.
What are specific methods and great resources for teaching exciting and meaningful science?

Do what you can, with what you have, where you are.

This was Teddy Roosevelt’s succinct reply to his field generals when they informed him they were unprepared and overmatched.

Jennifer sat alone in her empty classroom, head in her hands, with cardboard boxes of pencils, glue sticks, construction paper, and math games still unpacked and the bulletin board display she had crafted so carefully splayed around her on her desk. A 3rd grade classroom teacher for nearly 20 years, she thought back to the Chemistry for Kids workshop she attended on a professional day last spring. She remembered the energy and excitement she felt. “Science class can be the most exciting and fun part of the day for both students and teachers,” the speakers had told the group. The two science specialists from a nearby school had shown the initially skeptical group of teachers how to introduce the fundamentals of chemistry to elementary children, using a series of hands-on experiments. The room buzzed as the energized teachers dug into the first experiment. Jennifer had thought to herself at that time, “This will be the year I make it different! This will be the year I stop giving in to worksheets and texts.” But now it was a hot, still day in late August, and she was thinking, “What do I do now?”

Like Jennifer, many teachers struggle with meeting the needs of their most talented science students. How can these gifted students be challenged and learn as fast as they are able, especially in a classroom with a wide variety of abilities and interest in science? Many excellent teachers have found the answers in differentiating instruction by adding the inquiry method to their repertoire of science teaching methods.

Differentiation begins by recognizing that students start with diverse levels of readiness. Given this reality, the teacher plans instruction to vary content, the way it is learned, and student products. For example, in a chemistry unit focusing on mixtures and solutions, some advanced students might be ready to work with the concept of the mole, while most of the class learns about relative concentration and proportionality. Alternately, some students might be ready to design their own procedure for an experiment to measure relative concentration of solutions, while others use a teacher-generated procedure. Differentiation attempts to address the needs of each student, rather than assume that “one-size-fits-all.” Tomlinson (2004, 2001) has written extensively about differentiation and how to apply it across the curriculum.

The inquiry method can be summarized as “learning science by doing science.” Students employ progressively more sophisticated processes and technical skills as they learn increasingly more complicated scientific concepts and principles. It is essential that at every step, the learner be provided with not only a problem to solve but also with appropriate guidance. For example, early childhood students can use a tub and water tables to discover that water flows downhill, conforms to the shape of
Inquiring Minds, continued

its content, and that some objects float and others sink. A year later, an investigation using a wide variety of materials will reveal that solid metal objects like coins will sink while those made of wood will usually float. Thus, through the process of classification, students use their inference skills to make more complex conclusions about what floats and what sinks.

But some plastic objects float and others sink, and a toy boat made of metal may float while teak wood objects sink. Further experiments in middle elementary illustrate that both mass and volume are critical to understanding floating and buoyancy. By controlling variables, students see a linear relationship between mass and volume in buoyant objects. Such experimentation coupled with insight allowed Archimedes to solve the problem of the gold crown in what must have been one of the very first applications of forensic science. It also resulted in the scientific principle bearing his name and the development of the concept of density as an abstract mathematical relationship between volume and mass.

"Differentiation begins by recognizing that students start with diverse levels of readiness."

These individual investigations take place as the science student matures in the ability to conduct experiments. While there is no simple formula for developing a curricular progression such as that described for buoyancy principles above, the National Science Standards and inquiry curriculum developed cooperatively by experienced science teachers, science educators, and scientists, such as FOSS, STC, and GEMS, can provide guidance. Your own experience with children, whatever genuine questions they ask indicate the right starting point for investigation. Over time, you will see patterns to their questions that will enable you to guide them more efficiently. You may also notice an eerie fast-forward recapitulation of the history of science.

“No time like the present. Let’s start at the top with the big picture view,” thought Jennifer as she pulled out her three-ring binder with her curriculum plans, developed over many years. She grabbed a copy of Understanding by Design, a book recommended by a colleague, from her shelf and a pad of paper. She began to make notes and drawings on the pad and was soon working rapidly. A couple of hours later the boxes were still unpacked, but the tension in Jennifer’s shoulders had eased considerably. She looked with satisfaction at the pile of notes listing her goals for science for the year, the knowledge and skills she thought her students should have, some big ideas which seemed central to the content and connected the many concepts suggested by the state standards, some thought provoking questions that invited investigation, and some lesson ideas. This had seemed like an insurmountable hump, but she had gotten over it in a couple of hours. She was confident her year would be different as a result. Jennifer decided to continue this process and apply the Cycle of Inquiry Lesson Model presented in her workshop. “There, that’s a good start,” she thought as she grabbed her bag, deciding to go for a long delayed walk in the woods near her home before dinner with her family.

Switching from Direct Instruction to Inquiry

Direct instruction is generally defined as a method where the teacher presents the same content material to the whole class at once, sometimes with graphic aids like whiteboards or PowerPoint slides and sometimes with a demonstration to illustrate the concept. For gifted students, the pace of the instruction may move far too slowly, may ignore fascinating but difficult concepts, and may neglect entirely the opportunity to try out new or creative ideas. Effective direct instruction clearly has a role in science education, but in too many places direct instruction is used exclusively and perhaps exhaustively.

Probably the best way to switch from purely direct instruction to incorporating directed inquiry is to start with the big picture. Begin to think about moving from telling students about science to doing science with them. Think about switching from being a presenter, a sage on the stage, to a coaching role, a guide on the side. Shift from thinking about presenting a chunk of science content to posing an intriguing problem. Instead of focusing on covering a lot of content, think about working with your class to solve the problem, sometimes as a director, sometimes as a guide, sometimes as a sounding board. Understanding by Design (McTighe & Wiggins, 2004) offers an excellent presentation of a design process that supports the development of vital skills and content knowledge and facilitates inquiry.

Essential Questions and Big Ideas

What are the big ideas and the essential questions underlying this unit? Why did the textbook author include this unit? Why did the state department of education include this content in the state standards? Rather than thinking of an earth science unit as learning about rocks and minerals and the rock cycle, reformulate this unit in your mind to consider what the earth is made of and the dynamic processes that are continually reforming the planet. Plan the unit as learning about rocks and minerals and the rock cycle, as a detective story. Do your background research. Who discovered this information? When was it discovered and in what context? Was this a paradigm shifting discovery? Was there a controversy? Was this a serendipitous discovery? What is the story behind the scenes? What difference does it make? How does it change the existing and dominant theoretical framework? If you don’t understand why this stuff is important, neither will your students.

Now you are ready to design investigations around the
essential questions you identified. Essential questions will need to be converted into ones that are testable and specific. For example, the essential question, “Why does an object float?” can be simplified to the investigation question “Which of these objects float?”

**Applying a Lesson Design Model**

It is a misconception that inquiry lessons are free-form activity extravaganzas. It is true that students move toward greater independence in learning; however, they still require a basic structure for learning, as current brain research demonstrates (CDSL, 2000). While there are several good models for lesson design, our Cycle of Inquiry Lesson Model (Estes, 2007) is well suited to inquiry science.

This model consists of six steps.
1. The Hook
2. The Question
3. The Investigation
4. The Data Analysis
5. The Conclusion
6. Leading Questions

The **Hook** is a quick lead-in to the lesson that is funny, dramatic or surprising, and grabs attention while foreshadowing the investigation that follows. Mixing two colorless chemicals that turn bright blue in a flask, rolling a ball down an elaborate Rube Goldberg maze, or anything that makes a loud bang are time-tested classics. Bill Nye the Science Guy and the MythBusters are masters of this technique.

The **Question** phase allows you to reassess what the children already know and what they wonder about now through open-ended questions and dialogue. It is during this phase you pose the question or questions that will become the focal point for the investigation. These focal questions may come right from your design document and will further direct the attention of the students and activate prior knowledge from long-term memory. This phase is an excellent time to create “Know” and “Want to Know” charts with your students.

It is important to help students see the distinction between questions that can be answered by doing an investigation and those that can be answered through Internet or library searches. For example, 3rd graders can make “slime” from water, white glue, and borax and directly observe the changes in consistency and “bounciness” and “stretchiness” by altering the proportions of the ingredients. They can also make generalizations about what changes are produced by what changes in proportions. Naturally, they cannot directly observe atomic structure, work with strong acids, formulate highly abstract ideas such as Dalton’s atomic model, or spontaneously conceive of the concept of polymers. These ideas would be either presented or uncovered in searching other sources.

**The Investigation** is the heart of an inquiry lesson and provides the opportunity to observe, examine, test, and discover the key variables in the process of trying to answer focal questions. For example, in an investigation from the wonderful GEMS guide called *Cabbage Chemistry*, the children test different household substances like baking soda, rubbing alcohol, aspirin, and lemon juice to see how these substances affect the color of cabbage juice, which is a natural acid/base indicator. In direct instruction mode, you might tell the children they are going to learn about acids and bases, provide definitions, perhaps give a brief demo, and then read from the text about the important concepts concerning acids and bases. At the end, you might allow some exploration with the actual chemicals in order to verify and lock in the concepts. With inquiry, you begin by having the children mix the chemicals and observe. Over a series of exploratory lessons, students discover major concepts of acids and bases for themselves.

**Data Analysis** is integral to the investigation. For example, in the cabbage chemistry investigations, data tables are included to show what color each substance turned the cabbage juice, classification of substances by color group, and number of drops of a substance required to make a particular color of the indicator. Clearly the data analysis stage is a wonderful opportunity to apply math skills and to integrate the science and math curricula.

The **Conclusion** includes a reflective discussion to make sense of what was learned. It is here that students present their answers to the focal questions, supported by data, compared with other lab teams, and assessed with both logical arguments and creative thinking. At this stage, as consensus builds, you introduce definitions and provide validation of the concepts they have discovered. For example, you might say, “Scientists long ago observed the same color change reaction of cabbage juice to substances including lemon juice, vinegar, and aspirin that you have noticed today. They decided to call these substances acids.”

**The inquiry method can be summarized as learning science by doing science.”**

The **Leading Question** is the final stage in the cycle and leads back to the initial stage. Inquiry is more of a thought process, rather than a rigid, sequential unbending code of the scientific method. As the investigation process nears completion, the focal questions are resolved, and the dialogue reinforces major concepts. At this point, you may decide to close out the investigation by reflecting on the big ideas and the essential questions. This is a logical time to revisit the “Know” and “Want to Know” charts developed in the Questioning phase. Articulate what students have discovered and their key understandings of the Big Ideas in
the light of their discoveries. Any important questions still unanswered? What surprised them during the investigation? Was there anything they initially thought was true, but they discovered otherwise? What else do they want to try using the same investigation materials? What new questions do they have now? How do their discoveries fit in with the prevailing scientific theories of today? As in “real science,” this phase returns to the beginning of the cycle of inquiry and suggests further investigations and experiments. All the steps and stages in this model are covered in more depth in *Inquiry Science for Young Gifted Students* (Estes, 2007).

### Don’t Give Away the Ending

If you made the transition to presenting the unit as a detective story, rather than an encyclopedia entry and have created lessons based on a lesson design model, challenge the class with mysteries by using essential questions. Just as I wouldn’t hand you a new mystery book saying, “The butler did it,” you shouldn’t hand kids a mystery to solve and say, “Here is what you will find out when you complete this experiment.” Finding out “whodunit” is the point of reading a mystery book, and the answer to the essential question is the point of conducting an investigation. It is particularly difficult to resist the urge when students make incorrect predictions, but it is best to just say “Hmm…let’s find out!”

The first weeks of school flew by, and the class began to gel. Jennifer’s students loved being detectives, searching for clues, and solving mysteries. Jennifer reorganized her science units into mysteries to be solved. Hunting around the basement storage area in late August, she found a barely used FOSS science kit. This kit, called Structures of Life, covered most of the content required by her state standards. This year she organized her science time around the basement storage area and the answer to the essential question is the point of conducting an investigation. It is particularly difficult to resist the urge when students make incorrect predictions, but it is best to just say “Hmm…let’s find out!”

### Scaffolding Inquiry

There is some debate about the definition of inquiry science. Usually these discussions turn on how much of the investigation process is carried out independently, with some holding that anything less than total independence is not really inquiry, while others maintain that any hands-on activity is inquiry.

Clearly it is a big jump for a student to move from direct instruction to full-blown inquiry. The skills required for inquiry are complex and multilayered. Some teachers advocate waiting to use inquiry methods until students are in college or graduate school and ready to devote their careers to science.

The process skills required for full inquiry can be divided into a continuum of discrete and sequential steps. This developmental approach is like providing training wheels for some very complex skills (i.e., like designing an experiment with controlled variables). Ostlund (2005) calls this approach Scaffolded Inquiry. Initially the teacher provides essential learning support. This support progressively diminishes as students become more capable of independent work. Ostlund’s Scaffolded Inquiry has three stages: Directed Inquiry, Guided Inquiry, and Full Inquiry.

In the first stage, Directed Inquiry, the steps in each procedure are explained and practiced so that the student knows the goal, how to achieve that goal, and the tools needed. The sequence is highlighted, along with cues to indicate when to move to the next steps.

In Guided Inquiry, students work more independently, and the teacher acts more as a facilitator and less as a director. Guided Inquiry is a key stage for developing confidence in the students as they move away from step-by-step instruction.

Reaching the Full Inquiry stage is the ultimate goal for science students. At the level of Full Inquiry, they work independently to carry out their own investigations and function as scientists. They pose testable questions and generate alternative explanations. They systematically compare alternative explanations. Finally, they communicate their results to others for discussion, verification, and comparison. While this process is complex, it can be applied to very simple investigations. For example, a student could design and conduct a full inquiry investigation on the question, “Which liquid allows a plant to grow highest—water, juice, vinegar or cola?”

### The Next Step

The next logical step in removing the scaffolding piece by piece would be to have your students create their own procedures. You can begin by working as a class to write the procedure on the board for an investigation you have just introduced. You might also assign a homework problem asking them to write up a procedure for a slightly modified version of the experiment they just conducted. This will help you determine who can do this and who does not have a clue.

Another possible step is to assign a lab with a relatively simple experimental procedure and to give your students a choice. They can either take a direction sheet with the procedure...
given to them, or they can create their own procedure. You could also give the students a choice about whether to use a preconstructed data table or to figure out for themselves what data to record and how to record it. Students will tend to pick the choice that is appropriate for them. True, some will take the easy way and just grab the given procedure. But this also tells you something about either their confidence level or their motivation level.

It was May again. “Where has the year gone?” Jennifer wondered as she walked around her 3rd grade classroom. It was noisy in the room as her students happily conducted chemical tests of various household substances such as alum, talc, and baking soda, using investigations suggested by a newly purchased STC Chemical Tests kit. In December, several parents told Jennifer how much their children were enjoying science and offered to buy some materials for the classroom. Jennifer had been interested in this kit, and it made the perfect addition to her science materials. She and the class made the transition from a purely direct instruction model to a model that was mostly inquiry. Most of the students were in the realm of Guided Inquiry and were improving those skills along with learning important major concepts such as chemical reaction and crystallization. A few students, the ones whose gifts were in science, were suggesting ideas for experiments. Jennifer eagerly coached them as they designed and carried out their ideas. She groaned inwardly whenever she thought about her ambitious but ill advised forays into creating new materials in her first year using inquiry. “Keep it simple” was her mantra now. These students were beginning to appreciate the importance and difficulty of controlling variables. The changes had not been painless but had been worthwhile.

Jennifer did not limit her teaching to inquiry methods but used a variety of techniques. Sometimes direct instruction was the most effective way to convey essential material. She incorporated the history of science such as the Greek idea of matter and the four elements through an age appropriate book she read to the class. In addition, science definitions, while always discussed, reflected the accurate and accepted terminology, rather than the personal interpretation of each student.

Many teachers, like Jennifer, find that using a Scaffolded Inquiry Model helps them make what seems like a daunting transition to inquiry science much more manageable. Inquiry allows talented science students to dig deeper into a subject they love and challenge themselves. The Scaffolded Inquiry Model provides a framework for differentiation in the classroom. Jennifer found that her gifted students raised questions that she could not answer, so they worked together to find those answers. Direct Instruction can only proceed at the rate of the teacher’s own mastery of the material. While good inquiry science can be done with easily obtained materials from grocery stores, pharmacies, and hardware stores, having some solid, tested investigation based curriculum guides can help immensely.

For parents whose local schools are mired in traditional curriculum and methods, these resources provide a ray of hope and a pathway through the desert.

Resources:

Bill Nye the Science Guy
www.billnye.com/

Full Option Science System (FOSS)
www.fossweb.com/

Great Explorations in Math and Science (GEMS)
www.lawrencehallofscience.org/gems/

MythBusters
dsc.discovery.com/fansites/mythbusters/mythbusters.html

Science and Technology for Children (STC)
www.carolina.com/carolina_curriculum/stc/index.asp

TOPS Learning Systems (TOPS)
topscience.org/

References


Fred Estes, teacher of pre-kindergarten through university level for 25 years, is currently coordinator of the lower school science program and science specialist at Nueva School for gifted students in the San Francisco Bay Area.

Lisa Dettloff has taught and developed inquiry-based curriculum for 27 years. She is currently a Science Specialist at Nueva School in California.
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