Lift the Ceiling

Increase Rigor With Critical Thinking Skills

by Karen McCollister and Micheal F. Sayler

The optimal school learning environment for gifted students is one where scholastic rigor is the standard. This rigor is needed both to stimulate the students intellectually and enhance their academic growth. Whether enrolled in preschool, elementary, middle, or high school, the integration of critical thinking skills into the daily content and lessons is essential for achieving this rigor (Tomlinson, 2003). This infusion, along with also taking into account student interest, readiness, and learning styles, provides the foundation and walls for raising the ceiling of students' scholastic growth and intellectual stimulation.

The defining characteristic of gifted students is their advanced intellectual ability and its related needs (Sayler, 2009a). In order to appropriately address this cognitive aptitude, academic instruction must engage and inspire learners through complex curricula presented at a pace aligned to their intellectual and developmental readiness. The level of the advanced development of gifted students is often higher than their teachers suspect (Colangelo, 2007). Their readiness makes curriculum designed for most students at the typical age of the class developmentally inappropriate for those whose needs far exceed the norm.

Because gifted students more deeply internalize their understandings, they are ready to use logical thought and clear reasoning to gain new insights.

Differentiated critical thinking skills are one important avenue for teachers to engage and challenge the brightest students. Infusing good critical thinking activities in the classroom also helps those students on the normal developmental trajectory as they interrelate ideas within and among the disciplines leading to increased academic rigor and greater depth of understanding for them (Paul & Elder, 2007).

Intellectual giftedness is strongly related to critical thinking ability; however, critical thinking skills depend heavily on formal learning (Linn & Shore, 2008). Students with a strong knowledge base are better able to solve problems. Critical thinking is the art of carefully analyzing the ways we think with the purpose of improving it. Reasoning is an intellectual attempt to solve a problem or answer a question based on evidence in order to draw a conclusion or reach a decision (Paul & Elder, 2008). Critical thinking enhances academic growth; the more it is integrated into content instruction, the more students will analyze the concepts they are learning (Swartz & Parks, 1994). Four useful ways to integrate critical thinking into the curriculum are the inclusion of problem solving, asking questions that require critical analysis, evaluating sources, and decision making.

Problem Solving

Appropriately challenging problem-solving opportunities allow gifted students to apply critical thinking within any content area. Because gifted students more deeply internalize their understandings, they are ready to use logical thought and clear reasoning to gain new insights. Whether working in science, math, social studies, or language arts, critical thinkers are able to find connections across the disciplines. This broadens their opportunities to find unique, creative, and practical solutions to the problems posed.

An in-depth study into the effect of forces on the motion of objects provided an excellent avenue for fourth- and fifth-grade gifted students involved in a pullout math and science program. Critical thinking and scientific problem solving were infused into the physics work to enable the students to develop the understanding that change and constancy occur in systems and can be observed and measured as patterns. Physics is the science that studies forces and their interactions. Students with a strong knowledge base are better able to solve problems (Sternberg, 2006). The students explored background information through slideshows, specific websites, nonfiction books, and hands-on experiments. They studied the life of Isaac Newton; the laws of motion, gravity, and conservation of energy; and the formula for speed. Students were then invited to plan, design, and complete a small-group investigation to demonstrate their knowledge. Their task was to solve this problem: Plan, design, and complete an investigation using the "official materials" provided to demonstrate your understanding of the patterns that exist within the formula for speed. Using words, labeled drawings, and math equations, show your understanding of potential and kinetic energy and explain how change and constancy can be observed and measured in your system.

Small groups used marbles, ping pong balls, tennis balls, various foam insulator "tracks," ramps, tape, stopwatches, measuring tapes, strips of material, and other "official materials" to plan, design, and implement an investigation. During the investigation, they recorded observable and measurable data. Using written responses demonstrating correct nomenclature, along with labeled drawings, charts, and tables, they documented their understanding of force, motion, gravity, energy, and speed, along with their observations and measurements of change and constancy.

The students explained how the pattern for speed would change when distance was no longer constant. Austin wrote, "When we lengthened our track, our time increased. We also noticed a cool pattern in the transfer of energy when we created hills and loops, which we showed on our labeled diagram."

There was evidence of understanding when the variables of time and speed were changed. Sarah recorded:

> Given a constant distance, changes in time and speed vary by the amount of friction on the track. A track with minimal

> friction has greater speed than a track with greater friction. We added bumpy tape ridges on one track. Our time increased and our speed decreased. On the track without obstacles, the marble traveled more quickly.

The students' journal entries displayed with clarity their understanding of the problem. Their labeled drawings, math applications, and text demonstrated logical thinking and clear insights, while providing evidence of their ability to apply critical thinking and scientific problem solving to demonstrate conceptual understanding.

Questioning

Appropriate questioning is an important means of differentiation and infusing critical thinking in academically rigorous learning environments. Content knowledge can be shaped into an engaging, thought-provoking academic experience when focused on questions eliciting depth of understanding. Questions can stimulate deeper thinking, provoke interest and inquiry, and spark additional questions, allowing for greater intellectual focus (Wiggins & McTighe, 2005).

Critical questioning raises the intellectual level of thinking in a classroom. To enhance precision or clarity more details may be requested (Paul & Elder, 2008). The teacher might ask, "Could you please elaborate on that point? Could you express your point in another way?" Good questions get students to look deeper and more broadly (Paul & Elder, 2008): "What patterns can you see in the details presented in these data? How might your opinion change if you considered this information from a different point of view?"

An inquiry learning-based project allows students to use a question as a starting point in explorations that will build their conceptual knowledge. Scientific inquiries involve the learners in forming a better understanding of the questions. Students investigate, gather evidence, and formulate answers to the guiding question and record unanswered questions. Their questions guide them in communicating their results and conclusions and clarifying their understandings. Fifth-grade students participated in an inquiry learning project to answer this question: "In what ways does the loss or gain of wetlands habitat impact the population of migrating waterfowl?" This guiding question and the many student-generated questions allowed them to develop an understanding of an ecosystem's carrying capacity.

After an initial WebQuest to gather information on the coastal wetlands of America, the students participated in a simulation where they took on the role of a population of water fowl (Council for Environmental Education, 2005). Through the use of fate cards, students experienced losses and gains of habitat through dredging, factory-building, oil spills, and natural disasters, with an occasional positive fate card such as, "New state legislation restricts the motorboat traffic on a large marsh, reducing the human disturbance to this wildlife area. Add one habitat to the stopover habitats."

Students charted the gains and losses of habitat and waterfowl population with each completed cycle. A cycle was moving from the breeding grounds to stopover habitats, on to winter habitats, and ending back at the breeding grounds. Each movement was tied to a randomly drawn fate card. Students became intensely involved in discussions of the guiding question. They used research, as well as mathematical data from the simulation, to provide evidence showing the teacher their ever-deepening understanding of the issues involved.

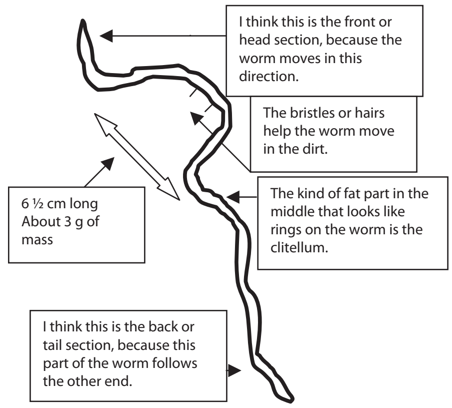
During a mock debate that followed the research and simulation, student environmental agents and oil company representatives engaged in point-counterpoint discussions concerning the gains and losses of wetlands habitat and the impact on migrating waterfowl. Using questions demonstrating clarity, precision, depth, and breadth, the students were academically engaged and deeply involved in science, math, and social studies content. The full scope of their understanding was clear when they switched roles and demonstrated their ability to debate from another point of view. Students' critical thinking showed a clear understanding of the deleterious impact the loss of wetland habitats have on waterfowl, along with their understanding of mathematical evidence and legal and commercial issues related to this complex problem.

Evaluation of Sources

Another method of enhancing academic rigor through the infusing of critical thinking skills is evaluation of sources. Research often involves gathering information from a variety of sources. Primary sources provide firsthand evidence of historical events, including photographs, letters, maps, and videos, and secondary sources are secondhand versions of primary source documents. In general, clearer data can come from primary sources; however, all sources need to be evaluated for their reliability. First, students find information that supports or disagrees with the statement under investigation. Before they accept the information, they check the credibility of the data. Students analyze the book, website, author, or article by scoring a checklist of source evaluation ques-

Name of scientific observer: Jacob **Date:** April 10 **Grade**: 3rd

Observations of an Earthworm		
Details to Observe	**Text/Measurements**	**Labeled Drawing**
Length of worm in centimeters	6 ½ cm	
Mass of worm in grams	Between 2 and 3 g	
Using a magnifying lens, look at the sides of the worm. Can you see bristle hairs? What is their purpose?	I think the little hairs sticking out help the worm move in the soil. They are kind of hard to see.	
Number of segments from the front end (anterior) of the worm to the clitellum.	There are about 16 segments. They go in and out like a slinky.	
Describe the difference between the anterior and posterior (back) sections of the worm.	The front and back look a lot alike, but the worm always moves in the same direction. I think the head leads the worm.	
Write your wonderings to guide your research here. You may add another paper if necessary.	I wonder if a worm has a brain. Does it have a heart that pumps blood? Do most people like worms or think they are gross? I wonder what worms do in the winter. Do they hibernate? Are there worms all over the world? How long is the longest worm? Are any worms dangerous? I wonder if the worm has predators besides birds. Do worms eat anything besides soil? Why do I see dead worms on the sidewalk at my house? Do special scientists study worms? Have worms ever been on a space shuttle?	



Directions:
1. Carefully place your earthworm on a wet paper towel.
2. Cover the worm lightly with a second wet paper towel.
3. Allow the worm to freely extend its body, as though it is crawling, when you measure it.
4. Use your spray bottle to keep the paper towels wet while you work with your worm.

Figure 1. Observation of an earthworm.

tions, including "What is the date of the publication?" and "What is the background of the author?" (Swartz & Parks, 1994).

Elementary students enjoy determining the reliability of content course information, authors, and publishing sources. While they do this, they are also developing the habit of evaluating all data for credibility rather than just believing everything they read or hear. To increase the level of interaction with content information further, students are encouraged to search for contradictory evidence from multiple sources that support or refute the claims.

Third-grade gifted students became "resident experts" (Winebrenner, 2000) in vermicology (the study of worms). First, they generated a chart of worm-related information that they believed to be true. They added a column of questions and "I wonder" statements. Then they composed a list of possible sources to determine accuracy and find answers for their questions and ponderings. Using the charted information, they began their in-depth study of worms. In Figure 1, you can read what Jacob recorded during his observation of an earthworm.

Savannah was absolutely certain that the longest worm reached a length of 15 centimeters. (In Figure 2, Savannah is measuring a worm.)

Imagine Savannah's surprise when she discovered that some tropical earthworms reached the length of 3.3 meters. She did not choose to believe this until she verified the author's credibility, as well as the reliability of the website where she located her fact.

This academic endeavor successfully met the curricular goal of understanding inherited traits, behaviors, and life cycles, and it allowed the students to become very sophisticated in validating information, evaluating reliability, and composing questions to verify information from valid experts as well. When Jesse suggested that all discrepancies in the information found should be color-coded, Carter designed an organizational method of handling the task:

> We need to cross-reference all of our facts with a minimum of two other sources. If the source agrees, record that on a blue

sticky note and put it over the question. If it disagrees, write it on a yellow sticky note and put it beside it. Then we can see which side is correct.

All of the other young scientists agreed that this extra step was necessary, and sticky note papers soon filled the charts.

To share the new things they had learned about worms, the students planned, designed, and served as vermicologists for a Wormology Lab Day for seven classes of third-grade students, teachers, and their own parents. The level of intellectual understanding was very impressive to all visiting the hands-on laboratory.

Audrey and Colin explained the humble earthworm's role in sustaining life on Earth, demonstrating their annelids preference for humus over sand and clay. As they discussed the worm's important role in aerating the soil, the children placed three worms into a clear container filled with three separate soil samples. Humus occupied the right third of the container, clay filled the middle section, and sand was on the left side of the container. When Audrey and Colin carefully released a worm into each section of the container, the worm in humus immediately wriggled under the surface of the soil. The worm placed on clay and the worm released on sand moved quickly to the humus section and also disappeared. The audience watched and listened with rapt attention.

Across from them, Lily and Spencer mesmerized the visitors with their models of the tropical giant of the annelid world, measuring exactly 3.3 meters, alongside a live worm. The resident experts answered each question completely and accurately, using information from their research notes and charts to support their responses.

Figure 2. Savannah measures a worm.

Students can become resident experts in any content area. Evaluating sources for reliability increases critical thinking, raises the level of academic rigor for students, and allows students to develop a rich conceptual base on their topic.

Decision Making

Infusing critical thinking through opportunities for decision making adds another avenue for increasing academic rigor for gifted elementary students. Decision making is used to select from among choices and evaluate opportunities both academically and in daily life (Sternberg, 2006). Students are taught to internalize guiding questions, so they can examine the possibilities involved in decision making carefully and constructively (Treffinger, 2008). Using metacognition, decision makers think explicitly about their thinking before and during decision making (Paul & Elder, 2007).

Students analyze the options available and then evaluate and weigh the merit of each option, enabling them to make decisions based on evidence. After jotting focus questions on a graphic organizer, such as a mind map, the decision makers evaluate the options and the consequences of each choice before making a judgment (Swartz & Parks, 1994). For example, "What are the options?" "What are the likely consequences of each option?" and "What is the relative importance of each consequence?"

Second- through fifth-grade gifted students in Austin, TX, lived through a flood, wildfire, and F-4 tornado in one 12-month period. The gifted team sought the advice of child psychologists concerning methods of overcoming the fear of natural disasters that happened that year. Through a physics-based project funded by Toyota TAPESTRY Grants for Teachers, students were invited to participate in an in-depth study of natural disasters within their geographic area for the purpose of internalizing safety information and sharing it with other children and adults in the community.

Following the Osborne-Parnes creative problem solving process (Treffinger, 2006) to guide decision making, students set a goal; gathered facts, data, and questions; focused on the central problem; generated possible solutions; selected their best solutions; and planned and finalized their presentation. After setting the goal of informing others of important safety facts related to local natural disasters, the students chose several of the options generated and weighed their practicality based on the chances for their success, cost, and time involved.

The gifted students decided to plan, design, and prepare a special Open House for the community, in order to provide safety information on wildfires, floods, and tornadoes. The students first completed a WebQuest to build their knowledge of the past local natural disasters, as well as other well-known American wildfires, floods, and tornadoes. They gathered facts and data, while generating new questions. Following the WebQuest, each child chose a topic of personal interest, with the goal of becoming a resident expert on the selected type of disaster, significant historical cases, and important safety information relative to that kind of disaster.

Gifted students must develop the capacity to think like experts (Mansilla & Gardner, 2008). After completing a second graphic organizer to analyze and evaluate presentation options, the students decided to provide hands-on lessons on the science behind each type of natural disaster, and related safety information through web pages, PowerPoint shows, brochures, and a wide variety of presentations on the history of significant natural disasters.

Each student chose a specific independent project that matched his or her individual talents, style, and interests. Students also participated in large- and small-group science, history, and math lessons. Logical-mathematical students created detailed graphs and charts of disaster-related information. Highly verbal-linguistic students opted to create original narratives and plays. One of the kinesthetic learners created and practiced an interpretive dance to tell the story of the 1925 Tri-State Tornado. Another pair of students created models of roofs in the area with detailed information regarding their safety in disasters. Two musically inclined students generated an original song, complete with music and lyrics to share their information. Artistically talented students presented their concepts using oil painting on canvas.

The class developed rubrics to evaluate the accuracy and success of the various safety presentations. After generating the necessary categories of projects, they met in small decision-making teams to design rubrics for each type of project. Using rubrics that they had helped developed over the year, the students determined the criteria most appropriate to their group's project category. As projects were completed, small teams viewed and scored each set of materials and presentation. They also suggested revisions and offered support as needed to prepare for the Open House.

On the night of the Open House, community members were captivated by storytellers, interpretive dancers, safety web sites, PowerPoint history programs, safe room blueprints and architectural models, oil-on-canvas historical disaster paintings, poetry, stories, and a gym full of hands-on science experiments, all planned, developed, evaluated, revised, and presented by the students. In response to student invitations, members of the local fire department and the American Red Cross, as well as a forest ranger from the Texas Department of Forestry, attended the Open House. American Red Cross members handed out their safety brochures alongside the students who handed out their safety fliers. A fireman brought his wildfire gear, and set up a table to demonstrate and answer questions alongside the second-grade wildfire experts. The Forest Ranger read the second-grade story of Smokey the Bear displayed on large, decorated stacked boxes. Several local roofers and builders complimented the roof-design team on the accuracy and appropriateness of their recommendations and display. The hands-on experiments were reviewed by local community members, along with an executive from the National Science Teacher's Association.

The level of academic rigor associated with this study was evident, as students shared in-depth knowledge of natural disasters and the critical safety points necessary when disaster strikes. Adult community members shared their respect for the students' work and their gratitude for the safety information presented. Critical thinking infused into decision making led to a very successful year of learning for the resident experts and enhanced the intellectually stimulating learning environment.

Optimal school learning environments for gifted students are ones where scholastic rigor is the standard. This rigor is needed both to stimulate the students intellectually and enhance their academic growth. We know gifted students are thriving when they are tenacious, perseverant, and persistent learners (Sayler, 2009b). They are able to attend to academically rigorous tasks for long periods without mental fatigue. The student engineers studying force and motion participated in all investigations with vigor and obvious interest. Besides the track investigations, they created other models to find the patterns associated with speed, time, distance, and gravitational potential energy. Before each class, students presented investigations that they had designed, implemented, and improved. These were not assigned tasks; these tenacious learners wanted to know more, so they created ways to do so.

Gifted students enter the classroom with a vast knowledge base and strong aptitudes. They need deep intellectual stimulation which in turn deepens and enlarges their existent knowledge base and lets them apply their special talents and gifts. This is true whether the gifted students have abilities as debaters, artists, writers, designers, mathematicians, or musicians (Hoh, 2008). The students who created the natural disaster Open House project worked for countless hours during class and beyond to develop their community safety information. They demonstrated their tenacity and perseverance as they created questions for adult experts, designed and carried out their own research, and imagined and created appropriate products. This deep involvement and complexity of learning was also evident in the questions and displays generated by the students investigating the loss and gain of wetlands habitats.

Educators must seek to understand the unmet needs of gifted students and provide curriculum that is at the levels and complexities that match their abilities. In turn, the gifted will flourish in such an environment as they experience, transfer, and internalize the deep thinking and complex content provided. Infusing critical thinking into all content areas provides an avenue for appropriately meeting these challenges.

After determining their students' readiness levels, personal interests, and styles of learning, teachers must create and deliver rigorous content, instruction, assessment, and product development through purposeful infusion of critical thinking. This raises the educational ceiling for gifted students, providing an enriching learning environment that stimulates intellectual development and academic growth. **GCT**

References

Colangelo, N. (2007). A nation deceived: How schools hold back America's brightest students. *Tempo*, *27*(4), 9.

Council for Environmental Education. (2005). *Project wild: K–12 curriculum and activity guide*. Houston, TX: Author.

Hoh, P. (2008). Cognitive characteristics of the gifted. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 57–84). Waco, TX: Prufrock Press.

Linn, B., & Shore, B. M. (2008). Critical thinking. In J. A. Plucker & C. M. Callahan (Eds.), *Critical issues and practices in gifted education* (pp. 155–166). Waco, TX: Prufrock Press.

Mansilla, V. B., & Gardner, H. (2008). Disciplining the mind. *Educational Leadership*, *65*(5), 14–20.

Paul, R., & Elder, L. (2007). *Critical thinking competency standards*. Dillon Beach, CA: Foundation for Critical Thinking.

Paul, R., & Elder, L. (2008). *Critical thinking concepts and tools* (5th ed.). Dillon Beach, CA: Foundation for Critical Thinking.

Sayler, M. (2009a). Intellectual growth, school, and thriving of the gifted. *Tempo*, *29*(1), 9–13.

Sayler, M. (2009b). Gifted and thriving: A deeper understanding of the meaning of GT. In L. Shavinina (Ed.), *The international handbook on giftedness* (pp. 215–230). Amsterdam, The Netherlands: Springer Science and Business Media.

Sternberg, R. (2006). *Cognitive psychology*. Belmont, CA: Thomson-Wadsworth.

Swartz, R. J., & Parks, S. (1994). *Infusing the teaching of critical and creative thinking into elementary instruction*. Pacific Grove, CA: Critical Thinking Press.

Tomlinson, C. (2003). *Fulfilling the promise of the differentiated classroom: Strategies and tools for responsive teaching*. Alexandria, VA: Association for Supervision and Curriculum Development

Treffinger, D. (2006). *Creative problem solving: An introduction* (4th ed.) Waco, TX: Prufrock Press.

Treffinger, D. (2008, Summer). Preparing creative and critical thinkers. *Educational Leadership, 65*(9). Retrieved from http://www.ascd.org/publications/educational_leadership/summer08/vol65/num09/Preparing_Creative_and_Critical_Thinkers.aspx

Wiggins, G., & McTighe, J. (2005). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Winebrenner, S. (2000). *Teaching gifted kids in the regular classroom: Strategies and techniques every teacher can use to meet the academic needs of the gifted and talented*. Minneapolis, MN: Free Spirit.

Suggested Books for Getting Started

Keeley, S. P., Eberle, F., & Farrin, L. (2005). *Uncovering student ideas in science*. Arlington, VA: National Science Teachers Association Press.

Harvey, S., & Goudvis, A. (2007). *Strategies that work: Teaching comprehension for understanding and engagement*. Portland, ME: Stenhouse.

Small, M. (2009). *Good questions: Great ways to differentiate mathematics instruction*. Amsterdam, NY: Teacher's College Press.

Willis, J. (2006). *Research-based strategies to ignite student learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Authors' Note

The names of all students mentioned in this article are pseudonyms.