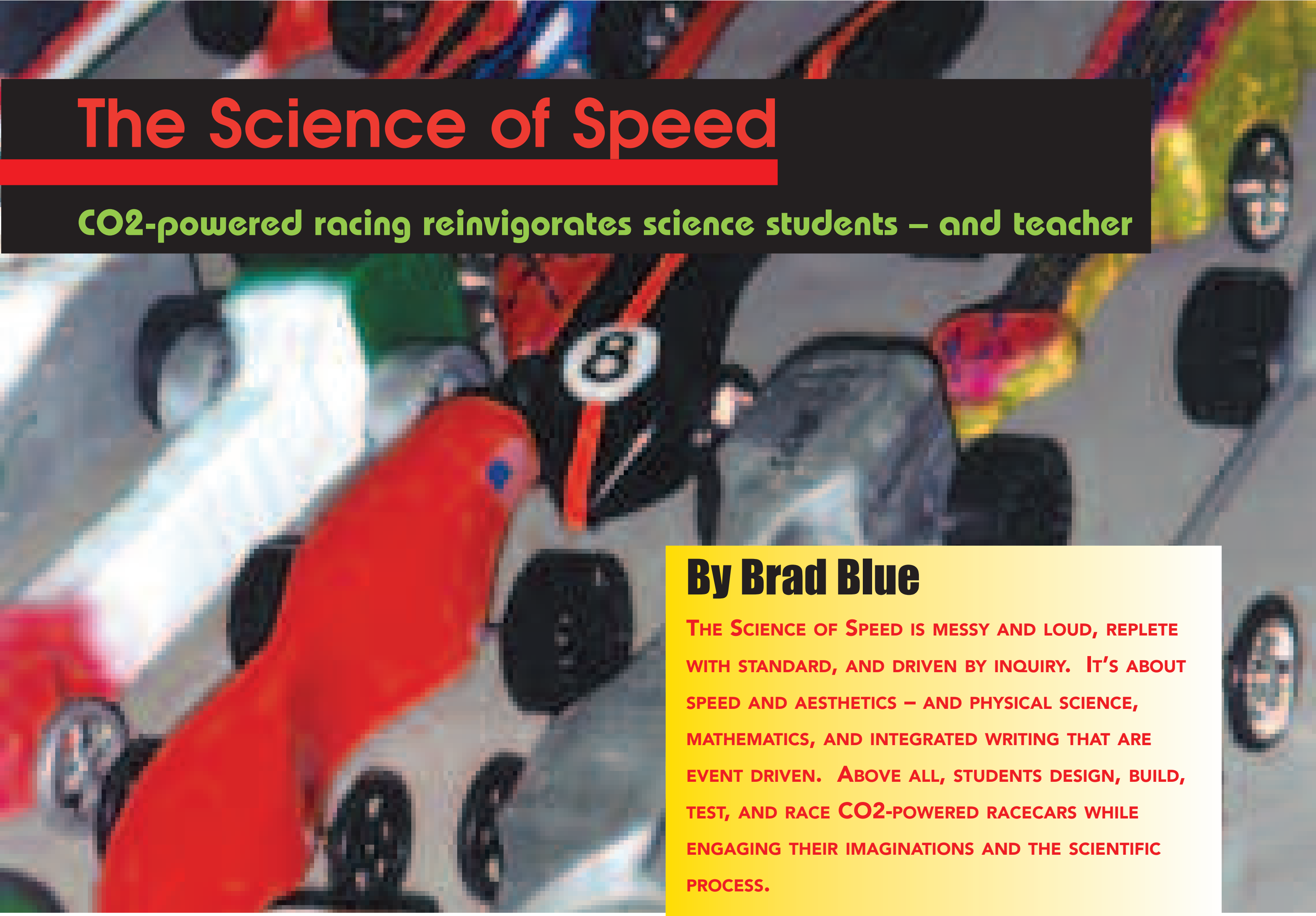

The Science of Speed

CO2-powered racing reinvigorates science students – and teacher

By Brad Blue

THE SCIENCE OF SPEED IS MESSY AND LOUD, REPLETE WITH STANDARD, AND DRIVEN BY INQUIRY. IT'S ABOUT SPEED AND AESTHETICS – AND PHYSICAL SCIENCE, MATHEMATICS, AND INTEGRATED WRITING THAT ARE EVENT DRIVEN. ABOVE ALL, STUDENTS DESIGN, BUILD, TEST, AND RACE CO2-POWERED RACECARS WHILE ENGAGING THEIR IMAGINATIONS AND THE SCIENTIFIC PROCESS.

More than a decade ago, I accepted a teaching post in a large, urban school district. Teaching middle school science would be much different than lecturing at a private liberal arts college, but I was ready for a change and a challenge. And I got more than I wanted – on the first day!

At the time, our district provided little support to science teachers. I vividly recall the horror of facing 30 adolescents with nothing more than a set of antiquated textbooks designed for a homogeneous class of self-motivated students. And then came another group of students 50 minutes later, followed by another and another — this went on all day, every day, until it was time to take school pictures!

The outdated textbooks actually augmented the penchant for behavior issues. The heterogeneous class included many students who were unable to read at the necessary level, and the textbooks were laden with nomenclature bereft of opportunities for application and tactile experiences. Effectively, the classroom was up for grabs, and while I later learned this was the case in many classrooms, I found no comfort or hope in knowing the same realities would face me every day.

Ten years later, I am delighted to report that I teach in the same district and enjoy unprecedented support. Moreover, the science classrooms are replete with exceptional learning materials.

I am delighted to be on this side of the decade. In retrospect, the lack of materials and support, as well as the poten tial rigidity of the classroom, necessitated creativity and reflection. I was forced to find and create relevant materials to engage students in science and discovery.

I wanted to avoid offering activities that would simply have curb appeal – thereby reducing discipline problems – but that lack coherence and reference to standards. I needed both. The space I have for this article precludes relating the sordid details of how I survived and how the students advanced. The scope of this piece is far more modest. It's about one particular activity that's exceptionally fun and dear to my educator's heart, The Science of Speed, a 16-phase process of designing and building CO2-powered racecars.

The Need for Lifelong Kindergarten

In the evening following my first day teaching middle school students, I reflected on the contrast between my experiences

and those of my firstborn who was in kindergarten. He and the house were covered with kindergarten. His clothing announced the activities of the day including the color of the paints he preferred. The refrigerator quickly became an art exhibit. Without solicitation he told all, and with little effort I could imagine the details of his day.

My task suddenly seemed obvious and simple: to create a milieu consonant with kindergarten and developmentally appropriate for middle school students. I read a telling, recommended article by Mitch Resnic, who suggested education needs to look at kindergarten as the paradigm for educational experiences. In a long tradition beginning with Froebel and followed by Pestalozzi, Resnic argued that children needed to learn through their senses and through physical activity.

Froebel's 20 gifts – manipulatives such as blocks and balls – have been given to kindergartners around the world for generations. Everyone loves kindergarten! The classrooms are alive, full of color, textures, and purposeful activities. Why, then, is this successful model and pedagogy subsequently abandoned as early as the first grade?

These observations are more than comments about learning styles; they have everything to do with common sense. Why abandon an effective pedagogy so that by the time students arrive in middle school, the classroom is bereft of the original gifts or their dynamic equivalents?

In fact, rather than adding to the repository year by year based on the developmental abilities of students, we take the few gifts from kindergarten and replace them with archaic structures that have never served good pedagogy. The transition into high school is no better. In fact, many students are tracked into the "higher" math and science courses based on their ability to survive without making things they can see, hear, and touch, i.e., they are willing to think conceptually, hypothetically, without reference to the senses.

Other students are relegated to the nonacademic tracks of applied math, consumer science, and so forth, without the opportunity to proceed to the "advanced," more conceptual courses.

The Science of Speed is a deliberate attempt to introduce "new gifts" while enhancing "old gifts" with the view that all students will have the opportunity to make ideas instead of trying to get the ideas, i.e., young learners need things before words and the concrete before the abstract. This is commonly referred to as constructivism.

Most of the gifts, or tools, have been around awhile: drills, sanders, sandpaper, graph paper, scroll saws, etc., while others are quite recent: wind tunnels, photo gates, simulation software, etc. Then there are tools to cut and fashion, record and measure, and simply explore. The Science of Speed is a modest attempt to bring together the best of the old and the new in special reference to pedagogy, tools, and ideas using physical science as the venue for instruction.

Getting It Right

There were a few givens: CO2-powered racing had to be motivating, doable, well structured, and replete with standards and curb appeal. Basically, it had to be sort of a Pinewood Derby on steroids: kids at work – and play – learning science, math, and other subjects without even realizing it.

I proceeded down this track, and class attendance increased exponentially. Hall conversations suddenly included science. Best of all, at the end of the day, we celebrated and even employed some of that science verbiage. I met some great folks outside the classroom. And inside those four walls, we learned and played, like kindergarten — the Resnic type. We learned science and math, applied technology, listened to some tunes, chatted, and became collegial. Oh, some would call it play. I still call it lifelong kindergarten. Yup, I am a kid at heart. And the hearts and minds of kids are important.

Progression: Design to Performance

Through trial and error I formulated a 16-phase process for The Science of Speed. Starting with a preliminary activity and proceeding through design, construction, testing, modification, racing, data collection, and analysis stages, the entire process requires approximately 30-40 hours of class time.

In the end, each student has a custom-built car capable of competing in the much-anticipated Day at the Races. But even more important than the CO2 car is the student's portfolio. Every phase is documented and includes corresponding datasheets, specifications, lists of materials, and instructions. Students simply get on board and experience the ride of their life, picking up intense science and math knowledge along the way.

Anyone who doubts this shop-class-type activity is "classroom worthy" in this day and age of standards and comprehensive assessments should look no further than The Science of Speed's 11 pages of correlations to national science, math, technology, and English standards.

The Science of Speed

The 16-Phase Process

Here is a brief summary or delineation of what occurs during the 16 phases of activity within The Science of Speed.

Phase 1:

Zoon Air Car and Preliminary Activities (5 hours)
Low-cost activity addresses principles consonant with those addressed in the CO2 investigation: motions and forces, transfer of energy, etc. Other germane preliminary activities, especially NASA materials, are also applicable.

Phase 2:

Design (graphics and layout) (4 hours)
Following design rules and specifications (all measurements are metric), students create thumbnail sketches and begin to design their cars using a "4-View Design Sheet." They track information in their portfolio.

Phase 3:

Design Phase (Go/No Go) (1 hour)
Students complete data entry for their designs, and the teacher evaluates plans to ensure they are within the predetermined rules and specifications. Students may use simulation software prior to drawing their designs on polystyrene and wood.

Phase 4:

Car Construction (5 hours)
Students use a variety of tools to cut a prototype from the polystyrene, and then they construct a wooden car based on their design. Cars are not "finished," but constructed to a point where students get a general idea of the shape and dimension of their cars.

Phase 5:

Collect Data (1 hour)
Students use a variety of devices such as scales, wind tunnel, smoke visualization tunnel, and roll test ramp to measure and test their models. Data is recorded.

Phase 6:

Trial Phase (Go/No Go) (1 hour)
Students submit their data sheets, which the teacher must check to ensure that design and data are acceptable and within the specified ranges of measurements.

Phase 7:

Trial Races (1 hour)
Not a head-to-head competition, the trial race is an opportunity to collect further data and times for the purposes of determining how to modify a car to improve performance.

Phase 8:
Collect Data (Mathematical Information) (1 hour)
Students take mathematical information gathered during trial races, sort it, and then decide which information they will represent graphically.

Phase 9:
Analyze Data (Interpretation) (2 hours)
Students learn how to make decisions based on the evidence they find within their data. Taking speed and aesthetics into account, students try to achieve a compromise so that form and function are in proper balance.

Phase 10:
Propose Technical Changes (Technical Writing) (2 hours)
Using a "Technical Changes Sheet," students complete a five-paragraph technical writing assignment in which they propose technical changes to their car, sketch some of their ideas, and predict race performance.

Phase 11:
Design Modifications and Detail (Implementation) (4 hours)
Students modify their cars according to their interpretations and proposals for changes. They also detail (paint, clear coat, etc.) the car and update their design documents to ensure accuracy.

Phase 12:
Race-Ready Phase (Go/No Go) (1 hour)
Students complete a "Race-Ready Phase Data Sheet" that reflects any changes made to a car during the design modifications and detail phase.

Phase 13:
Design and Aesthetic Judging (1 hour)
The teacher sets up a process for judging the cars based on specific criteria. A process of peer review can be arranged to ensure students are involved in judging the cars' aesthetic appearance.

Phase 14:
A Day at the Races (1 day for all classes)
This is the most anticipated day, the culminating event. Performance is emphasized with special attention paid to design modifications and prediction of performance made during the technical writing phase.

Phase 15:
Collect Data 1 hour)
Referring to points awarded during design and aesthetic judging, as well as race times achieved on race day, students present data and information on a "Final Data Sheet." Students with m2top-performing cars may qualify for advancement to school-wide or regional races.

Phase 16:
Final Submission (1 hour)
Students assemble their portfolio materials. Using a rubric, the teacher assesses students' efforts on comprehensiveness and accuracy of portfolio contents, not on race performance.

A science teacher can deliver all elements of The Science of Speed or collaborate with a technology, math, and/or language arts instructor to complete the interdisciplinary activity.

In our continuing efforts to create lifelong learners, we educators become more convinced that learning can and should be fun. The Science of Speed is an answer to that challenge as it provides engaging, hands-on, relevant experiences for science students every year. Our task is to create learning environments where that fun resonates as joy in learning so that the experiences we provide not only transport our students from the mundane to the magical within the four walls of the classroom, but also to the "kindergarten" in the world around them – a place where to learn is to play and to play is to learn.

Suggested Readings

Mitchel Resnic, "Technologies for Lifelong Kindergarten", *Educational Technology Research & Development.* Volume 46, number 4 (1998); also at http://mres.www.media.mit.edu/people/mres/

On the Web:
www.science-of-speed.com
www.shop-pitsco.com

Brad Blue coordinates GEMS - Girls in Engineering, Mathematics, and Science - for the Minneapolis Public School system (www.mn-gems.com) and continues to develop educational materials (most recently, Exploration Mars, LEGO, 2003) and meaningful, culminative experiences for students. He received his PhD from King's College, University of Aberdeen, Scotland, and the Presidential Award for Excellence in Mathematics and Science Teaching.