

## Microscopy Education

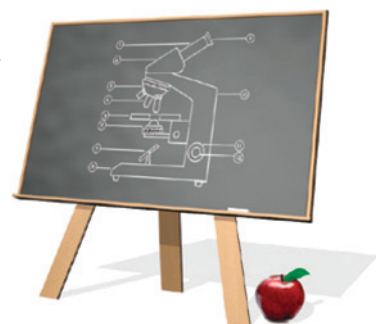
# The Private Eye – (5×) Looking/Thinking by Analogy<sup>®</sup>

## Magnifying Minds Using a Jeweler's Loupe, Everyday Objects, and a Few Simple Questions

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*Editor's Note: Kerry Ruef is the Founder and Director of The Private Eye Project. There will be a workshop concerning The Private Eye at the M&M 2015 meeting in Portland, OR.*

### Enchanting Worlds

Near some moss-covered rocks just outside the elementary school in Cascade Locks, Oregon, two fifth-grade girls hover over a tall fern. One studies a frond with a 5× loupe while the other acts as secretary and writes what her partner says, “Ooh, little swords. The edges are like saw blades.” The speaker straightens to look at the fern without her loupe and says, “The whole thing looks like a fountain.” She bends back down and turns the frond over, returning to her loupe-view: “I see brown hairs. And rows of tiny buttons. Like armies. Or are those bugs?” Her partner stops writing to take a closer look for herself (Figure 1).

Meanwhile, in a classroom at Washington Middle School in Seattle, students are lost in a maze of ridges and valleys—on their own fingerprints. They loupe-draw them carefully, like little topo-maps, inside six-inch squares, but in a week, each

drawing will bloom into large works of art that ultimately hang in the cafeteria (Figure 2). The art teacher and science teacher make a team.

In Dr. Hassoun's anatomy class at Lansing Community College in Michigan, students loupe-peer into the puffed and quilted skin on the back of their hands and use their observations and associations to write poems (Yes! In a science class!) as part of an exploration into the structure and function of the characteristics of skin. One student writes, “The back of my hand... a desert/where the water table is low/but tiny hairs of cactus still grow.”

A world away, a class of students in Haiti crams together on narrow benches. With eye-loupes in hand, they study their fingerprints up close. Then they draw them on tiny pieces of paper—the first steps on a journey that melds the personal and the scientific (Figure 3).

These scenes repeat themselves. Under fluorescent lights at desks or outdoors at the beach, the garden, the desert, the pond, students find enchanting worlds natural and manmade: twigs, shells, coins, strawberries, pond critters, fabric. These students share something in common: they are exploring the world with The Private Eye.

### What is The Private Eye? How Does it Magnify Minds?

**Thinking by analogy.** The Private Eye is a hands-on, interdisciplinary inquiry method that develops critical thinking skills, creativity, and scientific literacy across subjects, K–16, through life. Student-centered, literacy-rich, and art-rich, it begins with everyday objects, four simple but powerful questions, and a 5× jeweler's loupe—an unexpectedly humble magnification tool that fosters wonder and concentration and starts a surprising journey. The process and lessons are detailed in a book: *The Private Eye – (5×) Looking/Thinking by Analogy – A Guide to Developing the Interdisciplinary Mind* [1].

The goal of using The Private Eye systematically across the curriculum is to accelerate learning for all students. The method enables students to develop the habits of mind



Figure 1: Two fifth-graders find a fern forest surprise, through a loupe.



**Figure 2:** Fingerprint drawing blooms into a poster-size artwork by a middle school student.

essential for success in school and in life: looking closely, thinking and inferring by analogy, and learning to change scale in one's thinking, hypothesizing, inventing, and problem solving in all subjects. In the process, students write-across-the-curriculum with high-level results. They develop motivational bridges to content areas, recall content more easily, and make sophisticated and scholarly investigation into content areas simpler.

When Nobel laureate Joshua Lederberg was asked “How does a scientist think?” he answered, “I don't think there is one logic for science and another logic for the commonsense world. If there were, we would be in real trouble..... I'd say the ability to discover analogies, the ability to generalize, the ability to strip to the essential attributes of some actor in the process—the ability to imagine oneself inside of a biological or other situation—these are some of the pretty obvious talents.”[2]

**Growth of the program.** I started The Private Eye Project over twenty-five years ago, introducing loupes and a novel “thinking by analogy” process to the world of education. Analogical thinking is at the heart of cognition. Naturalize it in the curriculum, and student achievement improves. Originally grant-funded and piloted in Seattle's public schools, this independent program is currently being used in thousands of classrooms, homeschools, universities, and outreach programs in all fifty states and has spread to educators in a half-dozen other countries. To date it has reached over three million students.

Workshops and courses help school personnel integrate the program into their curricula (Figure 4). At Portland State University, in Oregon, The Private Eye is a collaborating partner with the Portland Metro STEM Partnership. We are in our fourth year of offering professional development to teachers in a graduate-level course integrating STEM and the Next Generation Science Standards [3]. Carol Biskupic Knight, Director of the STEM Teachers Academy for The Portland Metro STEM Partnership, explains the collaboration: “The Private Eye Program stresses interdisciplinary and connected thinking. The three-dimensional instruction and learning called for in the Next Generation Science Standards is the premise of The Private Eye. Focused, coherent, and engaging instruction allows for problem



**Figure 3:** School girls in Haiti discover and draw their fingerprints.



**Figure 4:** The Private Eye offers 1–5 day courses and workshops and follow-up courses and workshops. Seen here are teachers participating in a one-day Private Eye Workshop for K–12 hosted by the Oregon Coast STEM Hub at the Oregon Institute of Marine Biology in Charleston, OR.

solving, decision making, explaining real world phenomena, and integrating new ideas.”

To learn more about the program, view the website [www.the-private-eye.com](http://www.the-private-eye.com). This website has lists of materials needed, instructional strategies, standards correlations, and many rave reviews. There are also galleries of student work from grades 1 to 13 and examples of successful funding initiatives.

### A Brief Tour of The Private Eye Process

Science begins with close observation. So do art, fine writing, mathematics, and the social sciences. Slowing down, looking closely at the world (or some part of the world), noticing details and how they fit into some larger whole, and noting smaller patterns accumulating into larger

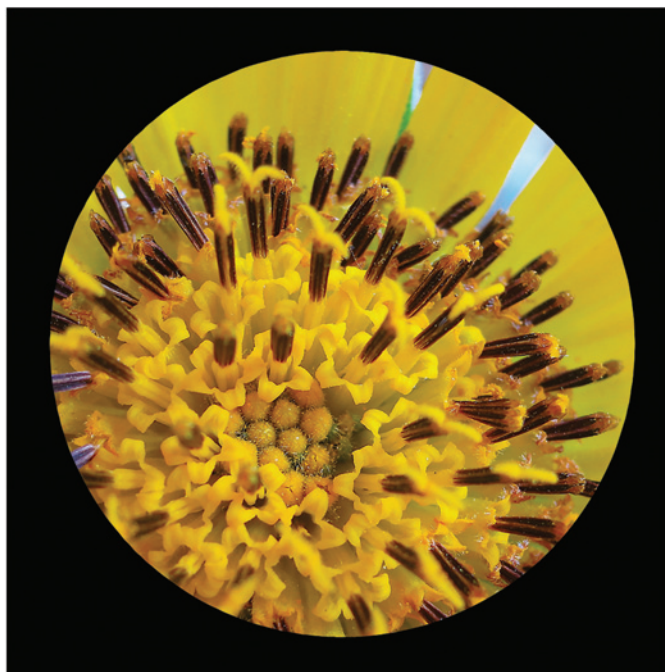


Figure 5: Student uses a 5× loupe to slide down a flower's throat.

patterns—paying attention with the senses—is the first door to any of these subjects.

**The loupe.** So how does a humble 5× jeweler's loupe open that door? The secret of the loupe begins in its design: its flared open end, pressed to the bones around the eye, cuts out competing visual stimuli. Take those distractions away and the modest magnification feels extreme. Five times magnification doesn't sound like much until the student tries it—and bam! He's sliding down a flower's throat (Figure 5); she's crawling into a seedpod or coming eye-to-eye with a cricket (Figure 6)! But this is only the start. The ultimate transformation takes something else.

**Four questions.** Learning to really *see*, it turns out, is not about merely looking closely. If George de Mestral had not closely observed the hooks on cockleburs and the loops on his socks, we would not have Velcro. But he didn't just observe, and consequently he invented and commercialized a useful product. A particular kind of paying attention is needed, one that is singularly efficient, one that involves simultaneously making connections: this thing is like that thing. I call it: looking and thinking by analogy. To make this easy, The Private Eye links the initial surprise in an observation to a question. As simple as it is, this question evokes thinking by analogy and binds the viewer to the subject: "What else does this remind me of? What else does it look like? What else?"

The question acts as a magnifier even as it acts as a connector. It keeps the observer looking, making fresh connections, and noticing underlying patterns—now memorable. All the while, a personal relationship with the blowsy dandelion, the thorny stem, or the worm in the soil is forming.

A wide range of research underscores the importance of connecting the personal and the emotional to the intellectual in order to engage, and hold, attention [4]. When students



Figure 6: Preschooler mesmerized by an Alice in Wonderland world.



Figure 7: The loupe-analogy list provides the "bones" for writing short and long pieces of prose and poetry.

write their answers down (aiming for ten or more), they produce a list of comparisons—analogy—in the form of metaphors and similes (Figure 7). These become the "bones-for-poems" and the scaffolding for stories, essays, and reflections. But they are also an exploration into the characteristics and properties of things. Thus begins the development of comparative, analogical thinking, heightened by asking "Why did it remind me of that?" How is a spider web like a bridge? How is a dandelion like an umbrella?

The third and fourth questions in the process lead to hypothesizing, design, and critique. "Why is it like that?" students ask when considering a phenomenon. They put their analogy lists to work as clues, gaining an understanding of the form-function link in nature by asking themselves the final question: "If it reminds me of \_\_\_\_\_, I wonder if it might function or work like that in some way?" Alternating between cooperative and independent work, students use their analogies to generate hypotheses that they test, chart results for, and decide on what to investigate further. In biology, for example, a student might use the loupe to examine the surface of a white fuzzy leaf from the plant



**Figure 8:** Who's looking at whom? Two nested loupes give 10× views.

Dusty Miller and compare it to fur. She might ask herself: “If the surface of this leaf reminds me of fur, I wonder if it might function or act like a kind of fur for the survival of the plant? How could it help the leaf/plant survive to have a kind of fur? And how would I test that?”

**Increased magnification.** The magnification journey begins at 5×; but two loupes may be nested for 10× (Figure 8). Fresh details emerge. Students delight in the shift from 5× to 10× and begin to experience what *scale* means, both physically and conceptually. If there are hidden wonders at 5× and 10×, think what awaits at 50×, 100×, and 10,000×. As students incrementally change the scale, they make new analogies, becoming more and more intimate with the world—the first step to falling in love with the world.

Note that a 5× loupe makes the world strange, but not too strange. Beginning the journey at 50× or 100× is simply too abstract for most students, even in high school and college. But starting close to human scale, adding personalized metaphors and similes along the way, it is easy to relate to the world fifty times bigger in the compound lab microscope. Continue this habit and students can leap to an interest in worlds thousands of times larger. Scanning electron microscopy (SEM) of loupe-viewed objects helps students extend the journey, which is why a gallery of SEM images by microscopist Dennis Kunkel is included in the book *The Private Eye — (5×) Looking/Thinking by Analogy*.

**Writing.** Back in the classroom, the fifth-graders from Cascade Locks elaborate on their lists. Each student writes a “sandwich poem,” an easy form where the title and the last line are the same. The middle of “the sandwich” is filled with favorite lines from a loupe-list. One girl hunches over her notebook and writes:

Fern  
A green fountain.  
The leaves are swords, the edges like teeth.  
There are hairs like rusty wires.  
And on the back, armies of tiny buttons.  
Fern

The students will use their starter loupe-list for extended nature journaling, for investigative essaying, or for setting



**Figure 9:** Loupe-drawing develops attention to detail, pattern sensitivity, and a sense of scale, even for those who think they cannot draw.

up hypotheses. *What are those “buttons” on the back? Why are they in rows? What do they do? Why do the tiny parts of the leaves look the same as the whole leaf? How can we test our ideas?*

**Drawing.** Soon the students begin to loupe-draw a leaf, a fallen pinecone, or a mossy twig. They move between loupe-studying the object and drawing a section of the object. It's the same with first-graders, high schoolers, or adults—the drawing process is absorbing. The loupe gives such intense visual feedback that even those who think they can't draw discover they can (Figure 9)! The activity develops pattern sensitivity, attention to detail, and a personal sense of what scale means (Figure 10). Furthermore, education research strongly supports the role of non-linguistic representation as a necessary component of conceptual development.

## Research on Learning

The basis of *The Private Eye's* instructional strategy was already in place in the 1960s and 1970s (for example, Piaget [5]; Brownowski [6]). This early work has been underscored by more recent neurocognitive and educational research, including the work of cognitive scientist Douglas Hofstadter, who broadly makes the case for analogy as “the core of cognition” [7]. When teachers and students move through *The Private Eye's* steps for writing, drawing, and hypothesizing, they engage in each of the nine most effective instructional strategies for raising student achievement noted by Marzano et al. [8]. Two examples of these nine strategies are: (a) identifying similarities and differences and (b) nonlinguistic representation.

**Similarities and differences.** If students develop a habit of identifying similarities and differences, achievement rises by a whopping 45% [8]. Students build this habit as they write their analogy lists while loupe-studying an object, as they repeatedly notice and discuss similarities and differences between an object and whatever else it reminds them of. There is even some recent work that points to identifying similarities as the subset of abstract reasoning accounting for the rise in IQ scores noted over the years [9].

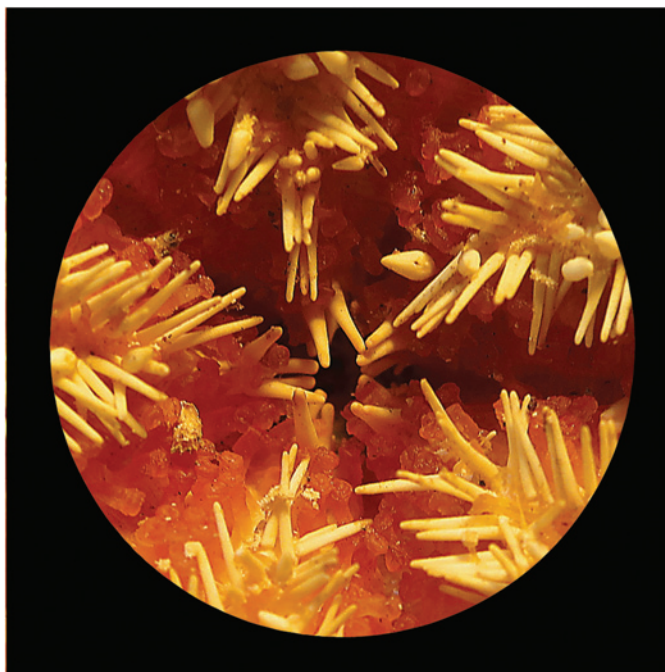


Figure 10: Pattern on the underside of a starfish (sea star) at 10x.

**Nonlinguistic representation.** Drawing with a loupe is a form of nonlinguistic representation. The more we use both systems of representation, linguistic and nonlinguistic, the better we are able to think about and recall knowledge. As students loupe-draw, they elaborate on knowledge gained when writing a loupe-analogy list as well as knowledge gained when connecting a loupe-subject to textbooks and other resources [8]. Moreover, drawing with the loupe integrates art into the curriculum, and art integration has been shown to improve test scores [10].

**Neurocognitive research.** Research into how people learn and, consequently, how we should be educating our students has been gathered and summarized by John Bransford et al. [11]. Neurocognitive research indicates that the brain is a dynamic organ, that it is *changed* by experience, by *how* kids are taught in school. It bolsters the case students can literally build into their lives the habits of mind embedded in The Private Eye process. Recent research also stresses the need for students to practice transfer of learning, the flexible adaptation of what is already known, to solving new problems and gaining new insights. Transference boosts student achievement [11]. Generating analogies, which students do in the first step of The Private Eye, followed by drawing cross-curricular connections, hypotheses, solutions, and insights from these analogies dramatically aids the transfer of learning. At the same time, students using The Private Eye process, regardless of the subject, engage in significant “place-based learning,” which research also solidly links to achievement [12].

### Habits of Mind

The Private Eye was founded on the premise that we are born thinking by analogy but that we can ramp that up in

school, at home, and throughout life. Analogizing is at the heart of original work, inventions, and solutions, be they literary, artistic, technological, mathematical, or scientific [7,13]. Because there is *no wrong answer* to The Private Eye Questions, students and adults bloom. They build habits of close observation and analogical thinking as they create their initial loupe-analogy lists and then use these “bones” for writing short and long pieces of increasing complexity and charm. Across genres, this writing exhibits the traits of voice, ideas, detail, and internal organization: traits necessary for high-quality writing [14]. Loupe-looking, loupe-writing analogies, and yes, loupe-drawing, unite as a springboard for compelling experiences of writing-across-the-curriculum. Research indicates that students improve their understanding of disciplines as they write in the context of those disciplines [15].

### Program Evaluation

**Teacher comments.** Teachers who have attended the Portland State University Private Eye STEM course, focused on grades K–6, report similar results to what teachers at all grade levels have said over the years. Fifth-grade teacher Christine Campanella, at Sitton Elementary in Portland, Oregon: “The most exciting part was the engagement of the students. ... We have used loupes on everything from dirt to coins to plants to parts of animals. And everywhere we go the kids are looking for connections: ‘That reminds me of... That makes me think of...’ Now they make connections from the beginning of the day to the end of the day.”

**Student self-assessment.** Students regularly report that their Private Eye work during the school year is a favorite. A typical comment from a third-grader at Alki Elementary in Seattle: “The Private Eye has changed my perspective of the world. Instead of just saying what it is, I think and say what it looks like. If I see something and I don’t know what it is, I put in analogies which help me find out what it is.”

**Wider evaluations.** The Private Eye has spread from teacher to teacher, parent to parent, professor to professor. Budget constraints have prevented a longitudinal study, and such studies are difficult to generalize from unless they are large. However, the accumulating force of research into how students learn and effective instructional practices underscores the program’s effect and its popularity. Research is currently underway at the Portland Metro STEM Center to determine the impact of The Private Eye on teacher effectiveness.

### Conclusion

With The Private Eye, students journey again and again into the drama and wonder of looking closely at the world, thinking by analogy, changing scale, hypothesizing, inventing, and problem solving in all subjects. The journey matters. It builds the most important habits of mind for success in school and in life. It magnifies minds.

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