
Generative Knowing in Education

An Example

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In December 2022, Henrike Holdrege and I taught the first two-week module of our course, “Seeing Nature Whole — A Goethean Approach,” in Florianopolis, Brazil. (The second two-week module will occur in December 2023.) There were 18 participants, whose professions included education, farming, art, therapy, engineering, veterinary medicine, nutrition science, and organizational consulting. This diverse group of individuals brought enthusiasm and sincere interest to the work. What follows is not so much a course report as an attempt to show a way of working. For that reason, I am writing the narrative in the present tense.

EACH DAY WE ENGAGE in three different kinds of activities: projective geometry, clay modeling, and plant study. At the outset it is not at all clear to participants how these activities relate to each other. Even though at the beginning of the course we say that we are not going to apply geometry to plants, there tends to be an underlying assumption that we will do just that. Why else would we offer geometry in a course? People know that scientists apply mathematics to model or explain natural phenomena. But that is not our intent in the course. We ask participants to be patient and to engage, and we hope they will see how the different activities enhance one another.

In all these areas — and at the heart of our efforts — we want to work experientially: We pay close attention to what we perceive, to the process of getting to know something, to how insights arise, and to the quality of questions and insights. We actively and consciously delve into a field of phenomena, consider them from a variety of perspectives, and attend to the relations and connections that show themselves.

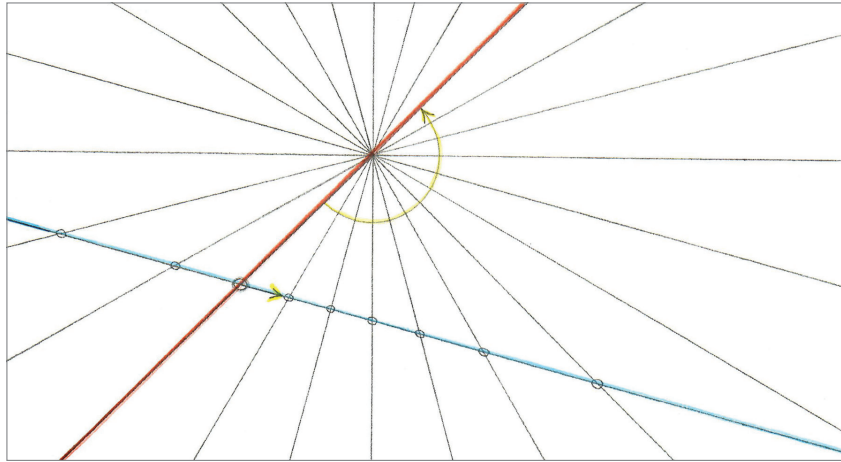
The work in projective geometry lies at one pole of human experience — the experience of concentrated thinking and of ideas that challenge our normal habits of thought. In a way we are asking participants to practice a kind of mental gymnastics that is disciplined, brings thinking into movement, and asks of them to move into unfamiliar territory that opens up new possibilities of conception.

At the other pole, we immerse ourselves in the vibrant and diverse plant life, which we study in the courtyard of the conference center where the course is held and also in

the nearby Restinga habitat. This is a shrubby woodland that stretches along the dunes close to the coast in this part of Brazil. We meet in perception a plethora of forms, colors, textures, and scents. The plant world reveals countless wonders. We encounter the riddles of life, growth, development, and death that plants present us with.

A third activity is clay modelling. Starting with clumps or small pieces of clay, we make geometrical forms; we sculpt forms with only planar, convex, or concave surfaces; we shape clay figures in which the different kinds of surfaces come to appearance; we create a series of forms that reflect a transformation. In these activities we are quietly present as embodied beings giving shape to material substance.

I can only hint at how these different activities support and illuminate each other during two weeks of concentrated collaborative effort. In projective geometry, we take a number of different thought paths. These are anchored through drawings that each person does and through exact picturing of geometric forms. The work leads to the central idea of the infinitely distant. This is at first a disturbing notion. Why? Because it necessitates that we leave behind concrete mental pictures. It is easy to comprehend that two lines have a crossing point, even if we have to imagine that crossing to be very far away. What about two parallel lines? In Euclidean geometry they are an exception to the rule and have no point in common. It was one of the key conceptual breakthroughs in projective geometry to conceive, for example, that parallel lines have a point in common in the infinite. (See the box, on the next page, for one entryway into conceiving of a common point at infinity.)



We draw the orange line and then the blue line with which it intersects. In our imagination, we rotate the orange line in a continuous movement counterclockwise by 180 degrees (yellow arc). It does not challenge our imagination to picture this continuous movement of the line rotating in a point.

Now consider the intersection of the rotating orange line with the blue line. The point of intersection moves to the right and returns from the left to the starting point! For finite picturing, there is a gap. When the intersection moves out to the right, there comes a moment at which the rotating orange line and the blue line are parallel. Here we cannot picture an intersection.

At the next moment, the intersection returns from the left, and we can comfortably picture again. For projective geometry, every line is a whole and has one point at infinity. (See Henrike Holdrege (2019) for a variety of pathways that together lead to an understanding of the infinitely distant.)

Instead of saying that parallel lines are an exception, projective geometry challenges us to conceive of a point we cannot picture. It says, “two parallel lines have a point at infinity in common.” For projective geometry, the points move continuously in one direction along the line through the infinite and return from the other back again. This too is a continuous movement.

The infinite in this conception is not an “ever-farther-and-farther-out-there” that you never reach. (This common view of “infinite” the philosopher Hegel called the “bad infinite.”) The infinite that projective geometry helps us to conceive of brings continuity to the whole of the line, plane, and to space when dealing with three dimensions. The wholeness in projective geometry is gained by including the infinite, that special and enigmatic “place” that we cannot picture. The understanding of it grows during many hours of work by considering a variety of geometrical phenomena, all of which first show their coherence when the infinitely distant is taken into account.

This new view has significant implications. First, wholeness includes a remarkable feature (the infinitely distant) that is not picturable but that is conceivable in clear rigorous thought. For example, in our typical (Euclidean) understanding, a triangle is a circumscribed figure that I can consider in isolation. There is the figure and the surrounding emptiness of the plane. In projective geometry we learn to consider the triangle as a three-sided figure (a trilateral) formed by three lines that extend through the infinite. In this way the trilateral configures the whole of the plane. The finite trilateral is one section of the plane and the sur-



rounding sections change when the shape of the trilateral changes. More generally, any figure in the plane, or body in three-dimensional space, is not isolated. It is related to the whole of the plane or of space. There is no such thing as an isolated thing.

While we are doing this work in geometry, at other times of the day we are modeling in clay and observing plants. We mold a clump of clay into a sphere and afterwards build up a sphere out of little pieces of clay. We add more little pieces and make the sphere into a cube. On another day we sculpt a tetrahedron. Before doing this work, we picture circles, spheres, cubes, and tetrahedrons in our imagination. We let them grow and shrink. We relate them to each other, for example, a sphere inside a cube such that the sides of the cube are tangent planes of the sphere.



When forming these bodies in clay, we have an idea that is at work in the movement of our hands. We can notice when the bodies come close to being right, and we notice imperfections. We notice them because the inner guide — the intuitive knowing of sphere, cube, and octahedron — informs our looking. Our seeing involves not only our eyes; we are seeing the outer bodies through our inner knowing. All this points to the very inner nature of geometrical forms, and at the same time to the wonder that we can give body to these forms through our own bodies.

We meet plants in the sense world. One focus can be attending to leaves — their shapes, colors, sizes, and textures. We encounter a remarkable variety of leaves—also within one plant. We look closely at them and picture their characteristics in our imaginations. In this inner re-creating, we conjure forth and move through the characteristics perceived and we present them vividly to our mind's eye. Such image-forming engages both will (the power of doing) and feeling (receptivity to qualities). I could also say

the activity of inner picturing is one in which memory, thinking, willing, and feeling are all at work.

After we take in some of the great variety that the plant world offers us, we ask: What is a leaf? In a given plant species we may discern a certain pattern in the way the leaves are shaped. We might say: the leaves of a given

species are usually between three and six inches long, generally planar with a longer or shorter stalk, and have an overall lancelet shape, often with pointed lobes and toothed margins. This is an abstract way of formulating what the leaves have in common (what Henri Bortoft calls “the least common denominator”). What it misses is that the specific leaf shapes are

not exactly predetermined and that no leaf is exactly like another. The leaves come into being. The plant creates

manifold leaves and there is no end to the possible shapes. We need to move from the idea of pattern to that of living formative tendency if we want to approach the reality of leaves. We approach the capacity of the plant to bring forth a multitude of forms and that capacity itself is no specific thing. We approach the generative life that is at work in

every leaf, as we approach the infinitely distant in geometry.

In working with clay, we ourselves are giving form to a malleable substance. After starting with geometrical forms, we move into the realm of convex and concave surfaces, and the many ways they can come into relation to each other. Our goal is not to imitate plant forms; we want to give expression to the formative elements of surfaces, edges



that arise between surfaces, and bodies that have different kinds of surfaces. In creating these we are agents shaping with those elements of form. Participants notice how the work in clay helps them in plant study to become receptive to the undulating form of a leaf, the full form of a swelling bud, or the unfolding of a flower. The forms become expressions of activity rather than static appearances viewed from without.



Another activity that helps us to approach the nature of formative potency entails observing and considering plants with the guiding question: Where and how do I perceive growth and decay in plants? Or to phrase it a bit differently: Where and how do I perceive coming into appearance and fading away, wilting and dying? We spend time looking at plants from this point of view. We perceive, for example, rounded forms (buds) at the center of a rosette of leaves; we see flowers that are only partially unfolded. The not-yet-fully-developed parts are tender in consistency, and of a different coloration than developed parts. We see drooping leaves and flowers, and ones that in their crinkled, dry, and skeletal form are scarcely visible remnants of living leaves and flowers. We participate in the different appearances of the plant, and consider them in relation to one another, both in the present and over time.

When we do this, growing, transforming, unfolding, and decaying reveal themselves to us as activities of the plant that we apprehend in momentary snapshots. We don't perceive growth as a sensory process happening continuously before our eyes. The moments are expressions of the plant as ongoing, unseen activity. The generative life itself never becomes visible in a thing-like way. Or I could also say: It is always potentially perceivable and becomes perceivable if we have the ability to see the mo-

mentary manifesting activity. This generative power is at work in all that comes to appearance and becomes visible to the mind's eye in the process of engaging with leaves, flowers, stems, and roots.

We enter in this way the realm that Goethe was pointing to with his idea of the archetypal plant ("Urpflanze"). Toward the end of his life Goethe looks back at what he considered to be the *discovery* of the archetypal plant. He speaks of "catching sight of it," of beholding in a "sensuous form" the "supersensible plant archetype" (Goethe 1989, p. 169). The archetype is not some abstract scheme; it is not an invention. It is the plant as generative activity that we can begin to glimpse when, to paraphrase Goethe, our perceiving becomes a thinking and our thinking a seeing (Goethe 1995, p. 39). Thinking here is not a mode of distanced consideration. It is a willful and receptive activity of being-with the phenomena.

Imagine that we are engaging with the plant in this way, and beforehand in the mornings doing the work in projective geometry I described above. The course participants are experiencing both in geometry and plant study that we approach thresholds in understanding. We are moving from what is concretely picturable to qualities that are not visible, yet clearly at work in the phenomena we are considering. This is exhilarating and challenging. By working in the two polar directions of intense sensory immersion and concentrated inner weaving of thoughts, we are stretching our capacities. In both directions the concrete picturable leads into glimpses of non-pictorial qualities — generative life in the plant and the infinitely distant in geometry. There is a delicate intimation that the two realms are related.

I mentioned above that when we take into account the infinitely distant in projective geometry, we no longer think of figures in the plane or space in the same way. Each figure is part of the configuration of the whole of plane or space, including the infinitely distant. In our picture of the world as one of tangible things, we have no trouble discerning boundaries between things — this chair is separate from that cup and from that person sitting on the chair. We are habituated to apprehending things as separate from each other, and then we may seek to understand how they may be connected. Projective geometry gives us one way of conceiving connectedness as fundamental — what we previously thought of in terms of separation, we discern as distinctions and differentiations within an integrated whole.

Plants lead us beyond "separateness thinking" in another way. One starting point is to consider that the plant does not create its body out of nothing. It needs what we typically call the environment. It needs light,

warmth, air, water, and minerals to create and maintain the substances of its body. We often say that the plant develops out of a seed. This is true. But it is also true to say: The environment becomes the plant through the seed. We need to hold these two thoughts together to approach the reality of the plant.



the potentials within the specific ecological environment (in which other plants are also involved). But what about the formative tendencies as such? What about the manifold ways of being a plant? Out of what formative environment, out of what generative world are they comprehensible?

Such questions don't lend themselves to clear-cut answers;

The plant as a separate thing is an artifact of separateness thinking. There is a plant-generating potency dormant “in” the seed and there is a plant-generating potency in the environment. When these become active, plants develop. Each plant is a particular realization of potency in the world, one focused point-like in the seed, the other a peripheral world of possibilities that we call environment.

In one way this plant-environment reality is easy to see and comprehend: A seed may germinate only after it has gone through a period of cold in the winter. The leaves of a plant growing in the shade will be different from those of one growing in full sunlight. The way roots develop are highly dependent on the character of the soil, but also on the above-ground conditions. The size of a plant and the degree to which it forms fewer or more leaves, roots, branches, flowers, fruits, and seeds are dependent on the environment in which it is growing. We can also say: In the way it grows, the plant expresses qualities of that elemental environment.

A riddle arises when we consider further. The specific form tendency of leaves in a species or genus — the differences between ash, maple, oak, or birch leaves — cannot be fully understood by considering the relation to sunlight, precipitation or some other “environmental factor.” This is also the case with the distinct formative tendencies of flowers in different plant genera and families. No doubt one finds, for example, many fascinating confluences of flower form and insect pollinators that show the connectedness of these two realms of life. But it remains a riddle that a flower type has three, four, five, six, or eight petals. In what we consider to be one environment there are manifold types of plants — different formative tendencies. The way they express themselves is dependent on

and if you attempt to give one, you notice that something dies. In a sense these questions are an expression of our having touched deeper and larger riddles of life. They are aspects of generative knowing — an enlivening opening, an awakening into the not-yet-known that also gives us a sense of the immense creativity at work in the world. It was the experience of these openings and riddles that, I think, led a couple of the participants at the end of this particular course to remark: “How could you possibly do plant study without also studying projective geometry?”



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