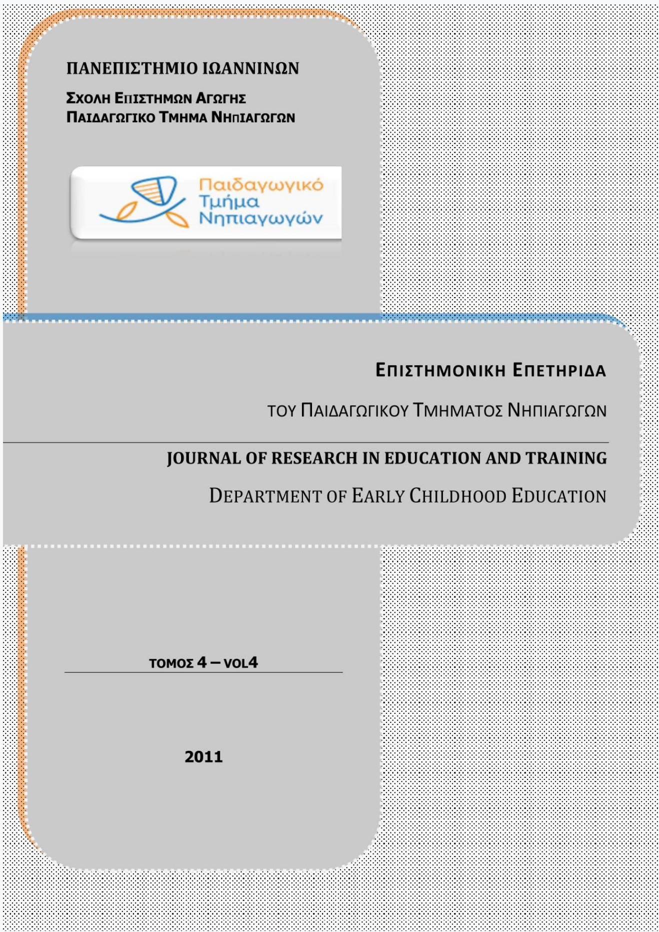
Επιστημονική Επετηρίδα Παιδαγωγικού Τμήματος Νηπιαγωγών Πανεπιστημίου Ιωαννίνων

Τόμ. 4 (2011)



Through the eyes of the learner

Wolff-Michael Roth

doi: [10.12681/jret.8705](https://doi.org/10.12681/jret.8705)

Wolff-Michael Roth

Through the eyes of the learner

ABSTRACT

Learning tends to be theorized, in research and curriculum practice, from the perspective of the known and seen, as is apparent in the idea that learners *intentionally* "construct" knowledge. We need to ask, however, how students who do not know the learning object (what the teacher wants them to know) can orient towards this unknown, unseen, and therefore unforeseen knowledge. The purpose of this paper is to bring the problematic of this learning paradox into sharp relieve by drawing on empirical examples from my research in a variety of settings. I then exhibit some core aspects of my findings, which, most importantly, highlight (a) the simultaneously active and passive aspects involved in any (perceptual) learning and (b) how the world and the objects it contains becomes independent of perception. I conclude by articulating some of the advantages that come with theorizing learning from the perspective of the learner – i.e., the perspective of the learning object as unknown, unseen, and unheard-of – including the often-forgotten emotional component.

KEYWORDS: Learning • cognition • perception • teaching • science

Representation is a presence that is presented, exposed, or exhibited. It is not, therefore, presence pure and simple: it is precisely not the immediacy of the being-posed-there but is rather that which draws presence out of this immediacy insofar as it puts a value on presence as some presence or another. (Nancy, 2005, p. 36)

Introduction

Learning means coming to know something new, something one does not already know. "But how can I intentionally aim at learning something that I do not know?" To give the question a concrete context: How could Christopher Columbus intentionally sail to the *Americas* given that he did not know they existed? This question that has come to be known under the name of *learning paradox* (Bereiter, 1985) but has never been satisfactorily answered though some have tried (Roth, 2011b). To frame the question in perceptual terms, how can I intentionally look for something that I do not already know and therefore do not know what it looks like? How can I take aim at something – like hunters aiming at game they intend to kill – that I have never seen or heard about, and therefore do not know? How can learners, in a science demonstration, know what to look for and therefore learn what the teacher wants them to learn? Take the following episode from an Australian 12th-grade classroom in the process of learning about the physics of rotational motion.

In this episode, the teacher sits on a rotating stool holding a bicycle wheel in his left hand (Figure 1a). He pulls on it (Figure 1b) so hard that the hand continues to travel after having let go of the wheel (Figure 1c). He then grabs the wheel again (Figure 1d). Just after Figure 1e, he utters, "Did you just see it?" The interrogative structure of the utterance – which has the grammatical form auxiliary verb-subject-main verb – and the rising intonation in the utterance toward the end both allow the culturally competent listener to hear a question. What were the students – who are presumed by the utterance to be culturally competent individuals – to have seen just prior to the utterance of the sentence? What can I see in the sequence of images when I do not already know what the demonstration is to exhibit? Was I to see that he pulled the wheel? Was I to see that my body moved a bit? That the teacher leans backwards? Was I to see that his foot touched the ground? That there is a potential ambiguity in the events can be taken from the fact that the teacher, when there was no response, invites the students again, "Look again!" He continues, "Look at my my my body, main[ly]." This instruction – if I, as a student, actually hear the utterance as such – tells me to look mainly at the body. That is, from the multitude of things that I can see, the movement of the hands and feet, it is *mainly the body* I am to look at. But what is it in the body that I am to look at and see?

Figure 1. A teacher shows a demonstration and then asks, "Did you see it?"

For the person competent in physics it appears to be self-evident that it is the body movement relative to the movement of the bicycle wheel that we are to see. Seen from the top – which the students do not do – the wheel spins counterclockwise whereas the body spins clockwise. When the teacher grabs the wheel (Figure 1d), his body moves counterclockwise back into its original position. That is, there are two complementary movements. *This* is what I have to see to understand that the lesson will be about the conservation of the angular momentum: it is zero to start with so that if a momentum is observed in the wheel an equal and opposite momentum has to be observable elsewhere in the system, here the body and seat of the stool.

Some readers may think these questions to be academic. It turns out that these are not academic questions but serious questions we need to pose and answer through appropriate research. Thus, in the Australian classroom, I had wondered what students were actually seeing while watching a demonstration like the one featured in Figure 1 (Roth, McRobbie, Lucas, & Boutonné, 1997). Several weeks after the students saw this one, we conducted a similar demonstration but asked them to write on a piece of paper what they *predict* to see. In the new demonstration, which the students had already seen before, the bicycle wheel was held such that its axle was perpendicular to the axle of the rotating stool. Because the two axles were perpendicular, the person should not rotate because there was no degree of freedom for the opposite movement so that the total angular momentum could be conserved. We then asked students to *observe* what they had seen and write it on their answer sheet. Finally, they were asked to provide an *explanation*. It turns out that out of the 23 students present, 18 clearly had seen movement and 5 clearly had not. When there are contradictory observations or explanations in the classroom, one popular teaching strategy among teachers is to count and "let the majority decide." In this situation, this would have been detrimental, for to be consistent with the theory, no movement, as predicted by five students, should have been seen. It turns out that these five students used explanations more or less consistent with the scientific canon. The explanations of the 18 students, though all rooted in physics, were inconsistent with the canon regarding this demonstration.

We now have to ask questions such as, "What sense did the students make of the original demonstration if they did not see what they were supposed to see?" The teacher clearly had used it prior to talking about the conservation laws concerning the angular momentum *L*, which were observed in the present case:

$$L_{wheel} = L_{body/stool} \tag{1}$$

or rather, because the total angular momentum was $L\ = 0$, the situation after he spun the wheel also has to add up to zero:

$$L_{wheel} + L_{body/stool} = 0 \tag{2}$$

Thus, if students had not seen *that* movement required for understanding equation 1 and equation 2 then there are serious problems, for they would have to somehow combine whatever they have seen and the equation that the teacher wrote on the chalkboard. If we, learning scientists, want to be serious about understanding learning, then we have to have explicit formulations of this problem: How can we expect students to intentionally orient toward and look for the learning object when they do not know it, have never heard of it (in an understanding way), and have never seen it? This situation is even worse than that of a host who has gone to the airport or train station to pick up the guest whom s/he does not know. How can the host identify the person when everyone coming off the plane or train is unfamiliar to them? We often see people standing there on the platforms or exits with signs containing names. In this situation the host are letting themselves be identified by the guest. The identification of the correct person then is the result of a donation, the guests giving themselves to be known, facilitated by the written name that serves as a mediating device. The notion of *donation* is deliberately borrowed from Marion (1998), because, as I outline below, learning something new is to a great extent something that *happens to or is given to us as* much as being the result of our intentional action. This passive dimension in learning is something, as I show in *Passibility* (Roth, 2011) both a challenge to constructivist approaches of all brands and a phenomenon generally not attended to by learning scientists.

In the preceding paragraph I note that the case of students in science classroom is worse than that of hosts looking for their unknown guests, for they know at least to be looking for a person. As seen in the preceding episode from my research, the students, not knowing physics, could not know what to look for – and, as my descriptions and questions suggest, there was so much to see. In the course of my research I have come to the conclusion that we need to think about learning, teaching, and curriculum development in terms of the *invisible* and *unseen*. What is invisible cannot be aimed at, a fact that can be expressed in French with the neologism *invisable* (based on the verb *viser*, to aim at). This then allows me to pursue the learning paradox in terms of a problematic already treated in philosophical terms: how the invisible and unseen comes to be seen in art (Henry, 1988; Marion, 2002) and the givenness as a fundamental dimension of human existence (Marion, 1997). Although I began to raise associated questions about 15 years ago, I have only recently developed the means to capture the problematic theoretically.

An Experiment in Learning Something New

During a stay in the section "Neurosciences and Cognitive Sciences" of the *Hanse Institute for Advanced Studies* (Delmenhorst, Germany) I took the stated problematic head on. While analyzing the videotapes collected during a 20-lesson tenth-grade high school physics course on static electricity, I also conducted an inquiry into the experience of learning and into the process of *coming to know*. I had been inspired by a series of publications concerning first- and third-person methods (e.g., Varela, 1996; Varela & Shear, 1999) and therefore kept daily notes not only about my learning while analyzing the video – my third-person perspective on learning – but also about things I noticed while riding the bicycle through the countryside for pleasure or while riding to the university. Most important for my research, I designed an experiment for the purpose of tracking knowing, learning, memory, noticing something for a first time, and so on. In this experiment, I would take the same tour for 20 days in a row. Each time preceding the trip, I would write down everything I anticipated seeing – an empty set {} on the first day, because I had never been where the trip would take me. Upon returning, I would note what I remembered having seen. The trip turned out to be about 25 km in length, taking me from the Institute outside the city, through valleys and field through an extended forest and back (Figure 2).

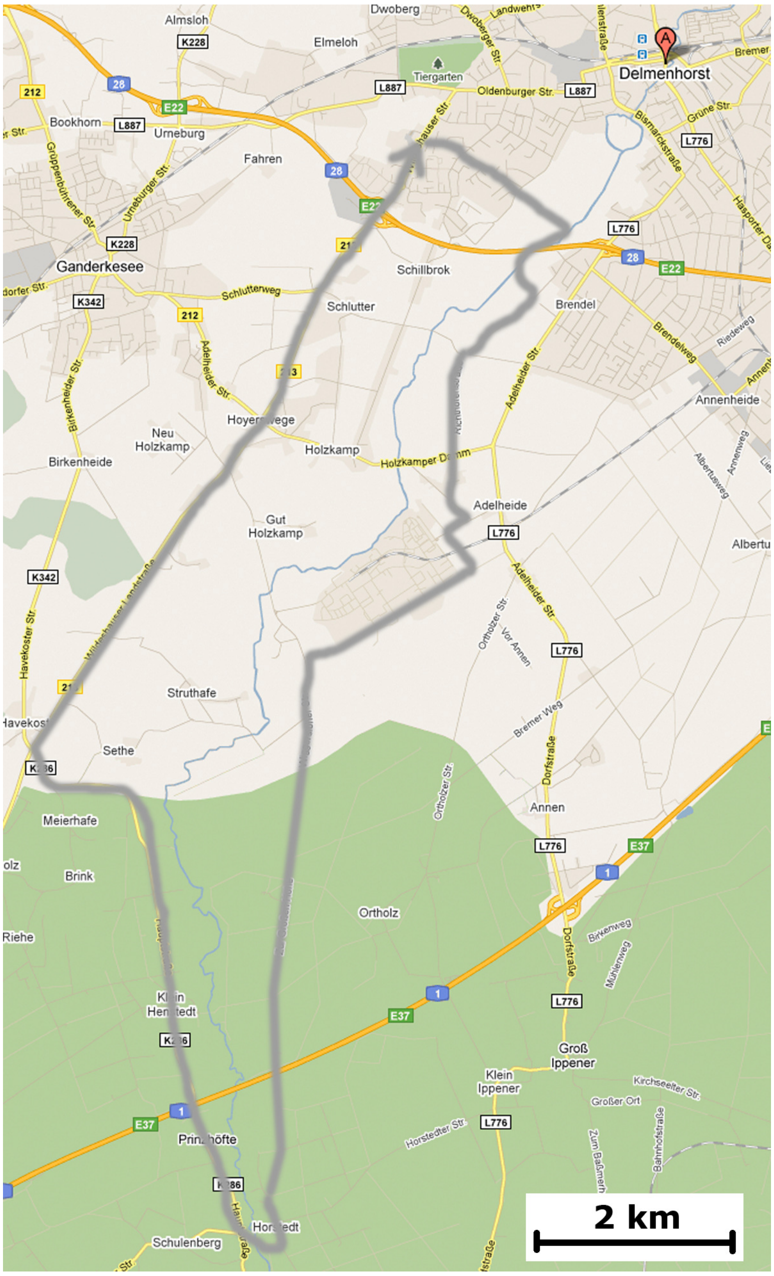


Figure 2. Map of the route taken for an experiment on learning and memory.

As the study unfolded, I noticed many interesting phenomena. But one stood out. Already on Day 5 of my experiment, I had noted, all of a sudden, white posts on the side of the road. Then I realized that they came in what appeared to be regular intervals. Finally, I discovered that every now and then there was a number associated with the post, which I took – because they changed following the pattern $n \pm 1$ – to be distance markers. Two days later, I was struck even more. On the side of the road I saw a set of twin silos. They were so big that they can easily be found on aerial photographs, sitting about 40 meters apart at a distance of 200 meters from the road (Figure 3). An entire slew of questions began to appear and unfold in my mind. How could I not have seen these twin silos on my first or at least second ride? I immediately realized that I could not have answered questions about the twin silos following my six earlier trips, and, during an examination, would have failed *even though the examiners could have thought that I had had already* six *times the experience*. I understood that I could not have aimed at seeing these twin silos precisely because I had no clue about their existence. I was in a situation not unlike that in which students find themselves when science teachers set up in "inquiry learning." How was I to know that these twin silos were relevant and not something else? There is nothing that "construction" of my experience would have allowed me to arrive at the twin silos, because nothing that *was given to me in my perception* would have lend itself as material to "construct" anything useful from it. An objection someone might raise is that a teacher could have told students to look for the twin silos. But in this case, the student would have had to know what a (twin) silo is. Even when there is the possibility of a mediational term, such as in the case of the physics classroom above where the teacher said, "Look at my my body, main[ly]," there is no guarantee that student see what the teacher intend them to see. As that research project in Australia showed, quite the contrary is the case.

Figure 3. The areal photograph gives an idea of the size of twin silos that only revealed themselves during the sixths trip past them and their distance from the road (bottom right).

Another important question during my inquiry was, "How did these shapes come to stand out against everything else as a ground?" Why these shapes and not some other shapes that could have become figure against ground in precisely the same setting? I attend to answering these questions in the next section. But let me return to the bicycle trip just after the twin silos emerged into my conscious awareness.

As the questions raced through my head, I experienced another shock: I realized that I had forgotten the world that existed for me before. Now I was thinking about a world populated with the twin towers, and I asked questions such as "How could I not have seen the twin silos?" These questions presupposed the existence of the silos prior to my first actual experience of them. I immediately realized that if there had been a teacher with me, presupposing a world in which the silos existed, would anticipate me, the student, to see the twin silos, whereas I could not intentionally look for them. And this, I realize today, is precisely where Jean Piaget and his constructivism are wrong. He assumed that there are (mathematical) structures in the world, which children (he considered them to be little scientists) can discover. Thus, he assumed children to look and interact with a balance beam and then, depending on their developmental stage, *abstract* a more or less mathematical pattern (Inhelder & Piaget, 1958). But to do so, one has to see the weight as weight and distance as distance, which is absolutely not the case even among older students who might see, for example, locations and number of objects suspended (e.g., Roth, 1998). Even mature scientists may see one aspect, such as the slope of the curve, when the relevant values required in solving a problem are the absolute values of the curve (Roth, Pozzer, & Han, 2005). There is nothing, I realized, that children can inherently abstract from the balance beam much in the same way that there was nothing for me to abstract the twin silos from the perceptual experience. *These things did not exist for me*. I lived in a world *without* twin silos.

For science teachers, *therein* lies the quandary. Having forgotten about the world without the twin tower, they can no longer *empathize* with the children and students, who inhabit a world that they have forgotten. They inhabit a world that they must forget unless they are to drown in the co-presence of all the worlds that they have lived in before. As I was able to experience, this world is in continuous flux because with every bicycle ride, there were so many new features that had come to stand out for me. Today, I know that learning is associated with a form of amnesia, a forgetting of the world in the ways we know it. To be an effective science teacher, therefore, I have to engage in a process of anamnesis, a process of recalling things past. I then understood an aspect of my own teaching: Because I had failed and therefore had to repeat fifth grade, I could understand that learning means struggle and not seeing what the teacher wanted me to see. *Listening* to students became more important than any effort in *telling* them something.

Learning and Intentionality

In the constructivist paradigm, claims are made about learning as the result of intentional engagement with the tasks that teachers pose to them; students are said to construct their knowledge (structures) to make them viable for navigating the world (e.g., von Glasersfeld, 1989). In fact, the constructivist theory begins with phenomena and associated concepts that any learning theory has to endeavor to explain: "the ability to establish recurrences in the flow of experience," "remembering and retrieving (re-presenting) experiences," and "the ability to make comparisons and judgments of similarity and difference" (p. 128). I show below how the perspective I develop explains the origin of remembering and representations that allow the establishment of recurrences. However, for many years, as science teacher and as researcher, I had also thought in the constructivist manner until I became increasingly dissatisfied with the blind spots of the theory. Thus, the experience of the twin silos and what I learned from it has changed the ways in which I think about learning generally and about its relation to intentionality specifically. But there is still a long way to go from this understanding to the point of having good examples and developing a good theoretical description. Both of these *came or were given to me* – perhaps because I was sensitized to a particular kind of need – in the way of (a) a familiar kind of image and (b) the phenomenology of perceptual learning.

First, in the course of our lives (at least in Western cultures), we encounter pictorial puzzles where we have to find something already known to their designers. Children are asked to find a certain (familiar) figure in a complex picture – as in the well-known children's book series "Where is Wally?" or "Where is Wally?" – and adults may be asked to find some thing hidden in a field of splotches (Figure 4). How can you look for something in such a field when you do not know what it is? You may look and look, perhaps rotate the page to look from another side. But if you do not know what to look for, there is little you can do until some *thing* is given to you in your perception. There is an extended invisible, and you cannot know what it might reveal. As soon as something appears as some thing, it is seen, just as something appeared to me that I came to know as the twin silos. This seen, as my experience had shown, after the fact is interpreted as having been something unseen before, no longer invisible but precisely unseen. When you look at Figure 4, the unseen that you are looking for remains, up to the point of its final appearance, unforeseen – unseen thus unforeseen. The unseen, or the unforeseen par excellence. Like death, which (in principle) is not here so long as I am here, the unseen remains inapparent as long as it is, and disappears the moment that it appears as visible. The unseen appears only in order to disappear as such. Further, one is not able in any way to foresee the new visible in terms of its unseen, which is by definition invisible. (Marion, 2004, p. 28)

Figure 4. A perceptual puzzle.

How can something inherently part of the invisible be seen if I cannot intent seeing it? It is that which I cannot see that must be part of its own emergence into my perception and consciousness. That is, the (now) visible must *itself* provoke the aim (intention) that renders it accessible. . . . The visible precedes the aim: this is what must be rendered visable by us, since we did not expect it. Coming among its own, it had to note that its own did not foresee it and therefore rendered itself [surrendered itself to being] visable by them. (p. 33)

Here we are confronted with an apparent contradiction, which only resolves itself in a dialectical perspective. The now visible must provoke the intention that makes it visible; but this happens when the now visible is not visible at all but, in retrospective, while it is still unseen. That which is seen precedes its aim. In other words, that which is seen cannot be anticipated because it does not exist for us. But together with itself, the now visible comes with the intention to see. Readers will be familiar with the perceptual puzzles where, after gazing a while or after someone shows (describes) what there is to be seen, one comes to see this thing. Now that we have seen this thing, we can easily regenerate it as often as we wish.

The quotation further points out that the now visible has come among its own, is visible among other visible things. But these other visible things did not allow the newly visible to be foreseen, much in the way I could not foresee the experience of seeing the twin silos from the other experiences along this country road. These twin silos *rendered themselves* (surrendered themselves) *visable*, something that can be aimed at, by everything visible to me at the moment. That is, to understand the way in which the newly visible comes into existence, I cannot think in terms of what is already seen, precisely because the visible "did not foresee it."

By the time readers arrive at this paragraph, I hope they have tried to see what there is to be seen in Figure 4. I have drawn the splotches such that once you know how to look, once the unseen has revealed itself and has become visible, you see the little Dalmatian dog. If you have not seen it yet – or if by some chance you have seen something else – you may want to return to find it. Now your search will be facilitated because you already know and have had perceptual experiences with dogs generally and with this kind of dog particularly. If I had said that there is a killer whale, you may still not be able to intentionally look for something, unless you know that this is the English name of what scientists refer to as *Orcinus orca*. That is, as long as we do not know what a word (scientific concept) refers to, it does not help us to be confronted with it: it is only a sound pattern. That is, if the Australian physics teacher above had told his students to look for the angular momentum, or had shown them arrows pointing up and down, the students would still not have had enough to *see* the phenomenon. They could not have seen it because, considered from an a posteriori perspective, the angular momentum was still hidden in the foliage from which the students had to extract it. That this was the case can be gauged from the fact that these Australian students did not understand a gesture by one of the researchers thought to be pun and therefore a joke.

The researcher in question had given the students a "thumbs up," by means of a familiar gesture that tends to be used as an alternative, stand alone expression: the hand being curled, thumbs sticking up (Figure 5a). Thumbs up is a sign of approval, acceptance, or encouragement. Viewed in this way, the researcher provided the students with some form of positive feedback or he might have thanked them for participating in the research project. But there is much more to it, only visible to the person already competent in physics. Unbeknownst to the students, the gesture is part of the answer to what they were to see and learn from the demonstration. They could not see this pun precisely because they did not know angular momentum so that the joke would be revealed to them only at the point when this learning object (angular momentum) also revealed itself to them. The gesture is the answer, and in fact a mnemonic device for thinking about angular momentum, where the "right hand rule" states that if an object rotates in the direction of the fingers of the fist, then the angular momentum is represented by a vector in the direction of the thumb (Figure 5b). Between the researchers, the joke was recognized, whereas the students, not yet knowing the concept of angular momentum *could not see* that the researcher had actually provided them with the correct answer to the problem they were working on. This can happen only when they see in the events of Figure 1 something that can be modeled by a physical concept denoted in Figure 5b, itself the signified of the thumbs up gesture in Figure 5a.

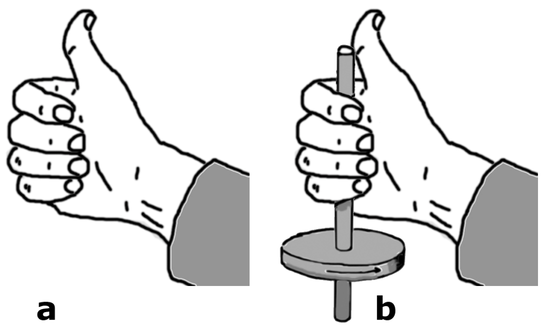


Figure 5. The "thumbs up" gesture (a) may in fact be a signifier of the "right-hand rule" (b), which relates the orientation of rotational motion and the vector of angular momentum (thumb) that represents it.

The Work of Seeing and the World as Independent Galilean Object

In the previous section I note that the seen precedes the aim, which may lead some readers to think that I am back to presupposing the physical world that exists independent of the living being. But this is not so. What I attempt to understand and theorize is how the world how something comes to be seen in a process evidently dependent on the perceiver and only then, by some process to be explained, takes on an existence independent of the world. Although philosophers have worked on this problem for quite some time, neither their interests in it nor their findings have made it into common knowledge or into scientific investigations of cognition.

It is generally well known that the world is not independent of perception for most organisms, which tend to be living in the here and now. This independence of the observer and the world itself is a historical achievement that was initiated by Galileo (e.g., Henry, 2004). A popular adage capturing this fact is "out of sight, out of mind," used frequently in the context of a dog that abandons a chase when the prey no longer is visible or when its scent is no longer present. Very young children, too, do not recognize the world as a feature populated with permanent though temporarily invisible features. Thus, "if a 7- or 8-month-old child is reaching for an object that is interesting to him and we suddenly put a screen between the object and him, he will act as if the object not only has disappeared but also is no longer accessible" (Piaget, 1970, p. 43). In fact, Piaget could have formulated this statement much stronger, and thereby have come closer to the truth. It is not so that the object has merely disappeared and is inaccessible. The object does not exist for him.

We, adults, do have experiences where objects are on the borderline between subjective experience and objective existence. For example, when we perceive a sound in the house and think someone is present. We might then walk about to check only to realize that whatever it was had been a figment of our imagination – unless we actually find someone (e.g., a thief) present. Scientists, too, have to go through all sorts of work to make sure they have a fact rather than an artefact of the investigation (Garfinkel, Lynch, & Livingston, 1981). When a signal in the laboratory comes to be recognized – in repeated trials under different, controlled conditions – they have discovered a fact; but when the signal does not recur or only sporadically and without apparent reason, the scientist constitute it to be an artefact.

If I had been a child, then the twin silos would not only have disappeared but also would not exist for me. Their existence would have been a function of my perception: when I see them, they exist; when I don't see them, they no longer exist. To exist independent of perception, the child has to become able to *make* the object *present again* even in its absence – the child has to be able to *re*present the object. It is precisely then that the objects specifically and the entire world generally becomes independent of perception. Without this capacity of re-presentation, a phenomenon would no longer exist once it has stopped (Husserl, 1980). That is, a child becomes capable of stepping out of pure Being (*sein*, εἶναι) precisely at the point when the capacity emerges to think Being in terms of beings (*Seiendes,* τὰ ὄντα) (Heidegger, 1977). *This* is what Nancy articulates in the quotation that opens this text – representation is not "presence pure and simple," "*not* the immediacy of the being-exposed there," but it is something that draws its own "presence out of this immediacy." For the adult, there already exists an independent world so that we experience a new object as something that was simply unseen prior to our first noticing. We update our representations of the world and forget the one that existed prior to the moment when the heretofore unseen revealed itself among other visible things. But, to reiterate the main point of this investigation, this independence of the world, the permanence of objects in their absence, is not possible without representation.

Up to this point, I we have not yet considered the following questions: "How does something come to be seen? and "Why, once we have seen it for a first time, we do remember it and can see it any time we so desire?" In the course of my inquiries into the learning paradox, the following exercise turned out to be very instructive. Take a look at Figure 6 before continuing to read. What do you see?

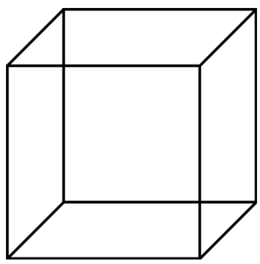


Figure 6. The Necker Cube.

The figure, known under the name of Necker Cube, is a well-known feature among perceptual scientists (psychologists). Despite consisting of black lines on a plane white surface, most people see one or both of two differently oriented cubes. One cube is seen from the bottom and extends to the back and left; the other cube is seen from the top and extends to the back and right (see Appendix). What is it that allows us to this or that cube? That is, what is it that allows us to see a three-dimensional figure where there are only lines on a flat surface? And, what is it that makes us see one versus the other cube? The answers reveal themselves when we try to quickly go from one cube to the other. Look at the figure so that you see the cube from the bottom extending backwards to the left. Close your eyes. Open them again but with the intention to see the cube from the top extending backwards to the right. Practice until you can quickly flicker your eyes and rapidly shift between the two perceptions. What are your eyes doing? You may realize that when your focus falls near the bottom intersection within the figure and moves parallel to "the exposed side" (i.e., parallel to the line from the intersection diagonally "backward" and left), then you see a cube from the bottom. Doing the same but from the upper intersection on the inside of the perimeter moving toward the right and "backward," then you see a cube from the top. That is, *what you see is a function of your eye movements!* The eye movements bring either one or the other cube to life. Without *this* movement, only lines will appear on the page. Moreover, without any movement at all – which takes a lot of practice or a special device that psychologist use to fix an image to a constant location on the retina – not even the lines will be present and the perceptual field would dissolve into an indistinct and indescript grey.

Some readers might think that this makes perception entirely subjective. But this is not so, as I was able to instruct others what to do to experience in the way I have experienced it. That is, the world is objective precisely because everyone can experience it in and through their subjective movement. Geometry is an objective science precisely because each individual human being can reproduce it – independent of location and historical time – in and through her actions, producing the same diagrams and proofs (Husserl, 1939).

We now have the first two elements required for understanding why the physics students see the motion that they were supposed to see or for me to see the twin silos. To see anything at all, the eyes have to move *between* the thing seen – the teacher, twin silos, lines – and the ground against which the figure comes to stand and stand out. A second kind of movement is required *within* the thing so that it can become *that* figure that it is. In the case of the twin silos, the eyes have to move so that the figure becomes a silo rather than something else; in the case of the cube, the eyes have to focus on a particular location within the context of the figure and then move in a particular direction for this or that cube to appear. In the case of the little dog, your eyes have to find the right beginning and then stabilize the internal movement required to see the structures of the dog and then move away from it to stabilize that figure against everything else, which becomes indistinct ground. But how do your eyes know how to move so that from the patches emerges a dog and so that from the lines emerges a cube (or two cubes in alternation)?

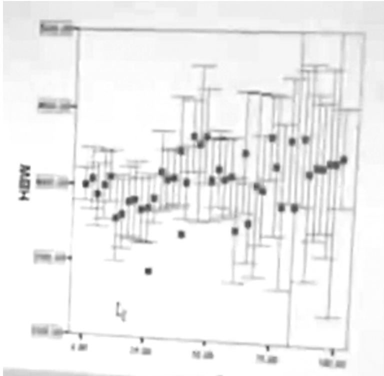
This is where Jean-Luc Marion in the quotation given above provides us with an answer. It is the thing itself that directs the eye even before the eyes voluntarily focus and follow certain features in a movement that makes the newly seen become visible. This movement lies entirely outside the realm of our intentions. We can provoke its coming by engaging a long time with the image, by looking, for example, for a long time at the splotches (Figure 4), by rotating the page, by squinting – that is, by means of many of the practices that in the past have helped us to see a situation differently, "under a different light," so to speak. The eyes are guided until a something suddenly appears, the twin silos, the Dalmatian doggy, one or the other cube. That is, *we are willing recipients, hosts, to this new thing that is* given to us *in our perception* rather than merely active constructors / interpreters of a pre-existing world.

The heretofore unseen reveals itself when the eyes have moved in a particular manner. Much in the way we become better at riding a bicycle, eyes become better at finding a doggy or cube in a display when they have done it a few times. Because the eyes can do these movements in the absence of the thing present, there repetition of *this* movement is the same as remembering the thing (Maine de Biran, 2006). The eyes do not require a special memory: their capacity to move in *this* way *is* their memory, an immanent and therefore immemorial memory (Henry, 2000). I have been able to show elsewhere that the hands might remember in and through the finger movement a telephone number that our minds have forgotten (Roth, 2011a). It is precisely this movement that hides behind the notion of representation, for as soon as it unfolds, the thing presents itself to our eyes again. (In fact, neuroscientists – e.g., Kohler et al., 2002 – have shown that the firing of the neurons responsible for the movement is accompanied by the firing of a set of mirror neurons. Whenever these neurons fire, we think of the thing, whether it is present or absent.)

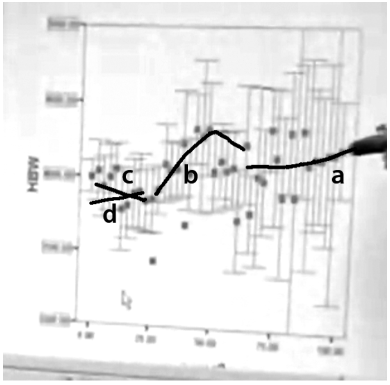
To understand why we come to see something heretofore unseen – i.e., why and how we learn something – we need to understand this passive entrainment that the eyes experience confronted with the world their movements come to reflect and constitute. If the mind had to direct the eyes, that is, to "construct" *de novo* the particular movement required, then the person might have to wait a long time before finding it, much longer in any case than any curriculum guideline can make available for a particular inquiry. We come to see because the movements of our eyes are in part entrained into movement trajectories ("kinetic melodies" the Russian psychologist Luria, 1973, calls them), which are equiprimordial with seeing the thing. Learning is both active – the eyes have to be moved – and passive – the eyes are entrained into the movement trajectory by the environment.

Some readers might be tempted to suggest that scientists for sure can see what there is to see. But this is not the case as my own research among scientists has shown. Time and again the question was raised about precisely what there is to be seen. Thus, in one instance, 6 scientists sit around a table. One of them projects different kinds of plots. Just as one of these appears (turn 109a), the lead scientist Carl gets up, walks to the screen where the graph is displayed, and tells the other scientists "what it looks like" (turn 110). Moving his hand through the image, he thereby invites the eyes of the other scientists to follow his hand. If they do so, then they will see what he already sees, that is, their eyes make the same movements that his eyes have already made. He now uses his hands – I marked the hand movement as lines in the associated video offprint next to turn 110 – to entrain the eyes of the other into a movement that will allow them to see what he already sees. They will see that "this here" is a line (a), and that the "sort of a component" is something that looks like an inverted parabola or Gaussian; finally he proposes two movements, one leading to an upward directed left-most part of the data, the other one a downward movement ("down again" [turn 111a]).

109a (3.90) * ((*new graph appears*)) (6.00)
110 C: so what it looks like is ((*gets up and walks to the screen*)) that weve got this::: (1.00)



Here (*draws imaginary straight line a on the rightmost of graph*)) and then weve got sort of a component in here ((*making arch gesture through middle of graph, b*)); and then it goes (0.68) ((*slightly upward movement, c*))



111 T: ah (0.23)
111a C: down again ((*gestures downwards at leftmost of graph, d*))

This episode shows us that Carl does not leave it up to chance that the others see what he can see. In fact, if the listeners do not follow his hand gesture, they might be forever looking for the "component," which comes into being precisely at the same time that the listeners' eyes do what the gesturing hand invites them to do, reproducing the movement prefigured by the latter.

Theorizing learning from the invisible and unseen

Learning tends to be theorized and thought about in terms of what is seen. The written curriculum and the use of demonstrations in the sciences are but two examples of how the seen dominates our thinking about learning and understanding. In English, saying "I see" is equivalent to saying "I understand." In this paper I show that from the perspective of the learner, the yet-to-be-known does not only announce itself in the seen but also is unforeseen, precisely because it is unseen. The way in which I knew the world around Delmenhorst did not allow me to anticipate the emergence of the twin silos; looking at the splotches in Figure 4, you could not know beforehand that there is a Dalmatian dog rather than a Holstein cow, killer whale, or something completely other that might reveal itself. Precisely because you did not know what you would eventually see, this subsequently seen cannot be used to think about learning *from the perspective of the learner.* To know what learners can or have to do, we need to think about learning from within their worlds and from within what is rational there. This means we have to think about learning from the perspective of a world that does not contain the twin silos, the Dalmatian doggy, or the different cubes. Because the twin silos did not exist for me, none of my decision-making processes could take them into account. From the outside, this might lead observers to thinking that I am irrational, when, in a situation where *they* would use the twin silos in their thinking or argumentation, I do not and cannot use it because unseen. Developing all the implications of such a perspective would clearly exceed by orders of magnitude the purpose and space for this text. Readers might be interested in my analysis of fourth-grade students learning algebraic generalization, where the student is confronted with the task to do something without knowing what it will yield, and where the teacher herself does not know what the student does not know and therefore has to learn as much as the student does (Roth & Radford, 2011). Instead, I articulate another aspect that comes with thinking learning from the unknown (unseen, unheard-of). This study allows us to understand that even in situations where there is teacher guidance, learning means confronting the unknown – i.e., the object/motive of the task – which reveals itself only when the student has learned what the teacher wanted him to learn. She could not reveal it *for him*, because, as I show above, he has to produce the required (mental, physical) movement that will reveal the learning object.

Learning is like a situation in which I do not know where I will eventually end up – such as traveling in unfamiliar terrain without a map. I may do this for a while, but if it is in the wilderness, eventually fear might set in, especially with the sense of being lost without food supplies, without equipment to keep us warm, sheltered, and fed. Our well being in the best of scenarios and our life in the worst-case scenario comes to be at stake. If learning is anything like confronting the unknown, unheard-of, and unseen, then we might readily accept similar emotional qualities of the experience we have. *E*-motion already enters the picture with motion and movement, because it is the mechanism that allows any living organism to "anticipate" possible outcomes of its movements and to assess the success or failure thereof (Leontyev, 1981). We can then understand learning something new as a continuous exposure to the unknown, uncertainty, and the emotional qualities that such situations entail for the individual. In fact, "I am lost" is a frequent comment students make in more traditional learning contexts, and is a reaction to the understanding that something is expected of them but that they cannot see it, literally and metaphorically. Some students more easily than others cope with such situations; others engage in engage in *defensive learning* (Holzkamp, 1993) that is, they learn anything that gets the task done without actually acquiring what the planned curriculum foresees.

Thinking about learning and the school curriculum in terms of the unknown, the invisible, the unseen, or the unheard-of orients us much better than other ways toward the problematic of learning captured in the learning paradox. Thinking in this manner forces us to theorize learning from the perspective of the learner, that is, from the perspective of the person who does not see and therefore cannot foresee what will befall him. My own research with respect to such a perspective is only at its beginning. There is a lot to be done to better understand the phenomenon of learning from the perspective of the learner; and there is a lot to be done to work out the practical implications of such a perspective for research, teaching, and curriculum development.

REFERENCES

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*, 201–226.

Garfinkel, H., Lynch, M., & Livingston, E. (1981). The work of a discovering science constructed with materials from the optically discovered pulsar. *Philosophy of the Social Sciences, 11*, 131–158.

Henry, M. (1988). *Voir l'invisible: Sur Kandinsky*. Paris, France: Presses Universitaires de France.

Henry, M. (2000). *Incarnation: Une philosophie de la chair*. Paris, France: Éditions du Seuil.

Henry, M. (2004). *Phénoménomenologie de la vie III : De l'art et du politique*. Paris, France: Presses Universitaires de France.

Heidegger, M. (1977). *Gesamtausgabe. I. Abteilung: Veröffentlichte Schriften 1914–1970 Band 5: Holzwege.* Frankfurt a/M, Germany: Vittorio Klostermann.

Holzkamp, K. (1993). *Lernen: Subjektwissenschaftliche Grundlegung*. Frankfurt a/M, Germany: Campus.

Husserl, E. (1939). Die Frage nach dem Ursprung der Geometrie als intentional-historisches Problem. *Revue internationale de philosophie, 1,* 203–225.

Husserl, E. (1980). *Vorlesungen zur Phänomenologie des inneren Zeitbewusstseins*. Tübingen, Germany: Max Niemeyer.

Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York, NY: Basic Books.

Kohler, E., Keysers, C., Umilta, M. A., Fogassi, L., Gallese, V., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: Action representation in mirror neurons. *Science, 297*, 846–848.

Leontyev, A. N. (1981). *Problems in the development of mind*. Moscow, Russia: Progress Publishers.

Luria, A. R. (1973). *The working brain: An introduction to neuropsychology*. New York, NY: Basic Books.

Maine de Biran, P. (2006). *Influence de l'habitude sur la faculté de penser*. Paris: L'Harmattan.

Marion, J.-L. (1998). *Étant donné: Essaie d'une phénoménologie de la donation.* Paris, France: Presses Universitaires de France.

Marion, J.-L. (2004). *The crossing of the visible*. Stanford, CA, Stanford University Press.

Nancy, J.-L. (2005). *The ground of the image.* New York, NY: Fordham University Press.

Piaget, J. (1970). *Genetic epistemology*. New York, NY: W. W. Norton.

Roth, W.-M. (1998). Starting small and with uncertainty: Toward a neurocomputational account of knowing and learning in science. *International Journal of Science Education, 20*, 1089–1105.

Roth, W.-M. (2011a). *Geometry as objective science in elementary classrooms: Mathematics in the flesh*. New York, NY: Routledge.

Roth, W.-M. (2011b). *Passibility: At the limits of the constructivist metaphor*. Dordrecht, The Netherlands: Springer.

Roth, W.-M., McRobbie, C., Lucas, K. B., & Boutonné, S. (1997). Why do students fail to learn from demonstrations? A social practice perspective on learning in physics. *Journal of Research in Science Teaching, 34*, 509–533.

Roth, W.-M., Pozzer-Ardenghi, L., & Han, J. (2005). *Critical graphicacy: Understanding visual representation practices in school science*. Dordrecht, The Nether-lands: Springer-Kluwer.

Roth, W.-M., & Radford, L. (2011). *A cultural-historical perspective on mathematics teaching and learning.* Rotterdam, The Netherlands: Sense Publishers.

Varela, F. J. (1996). Neurophenomenology: A methodological remedy for the hard problem. *Journal of Consciousness Studies, 3*, 330–350.

Varela, F. J., & Shear, J. (1999). *The view from within: First-person approaches to the study of consciousness*. Thorverton, UK: Imprint Academic.

von Glaserfeld, E. (1989). Cognition, construction of knowledge, and teaching. *Synthese, 80,* 121–140.

Appendix

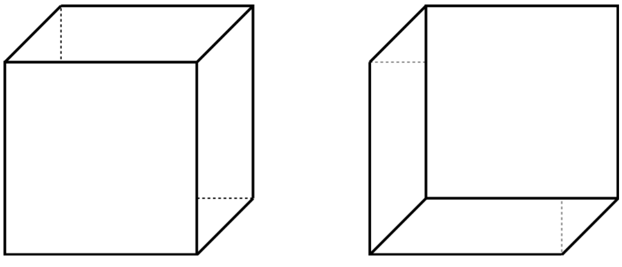


Figure 7. The Necker Cube with slightly modified line widths and opacities of one of the two squares gives rise to different perceptually experiences: a cube seen from the top extending to the right or a cube seen from the bottom extending to the left.