

## **Close Schools. Open Minds.**

### **Why We Need Educology to Improve Education**

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#### **Abstract**

'Educology' is 'knowledge' of 'education', that is recorded 'signs' of knowing' about 'intended' and 'guided learning'. Precisely defined terms are required so that 'educology' can be advanced, much as has been done in disciplines such as physics, biology, physiology and anatomy. Kinds of 'learning' are distinguished: 'accidental', 'discovery', 'conductive', and 'compelled learning'. 'Mental structures' for 'knowing that', 'knowing how', and 'knowing that one' are explicated through further definitions and examples. If we are to change 'education systems' for the better, then we must create 'worthwhile education', that is 'education' that is both 'instrumentally good' and 'intrinsically good'.

#### **Key words**

Educology, knowledge, education, education system, learning, knowing, signs, theory, universals, terminology, definitions, effective education, worthwhile education.

## 1. Overview

Close schools. Open minds. Am I serious?

Yes. But not the way you might initially think.

Does that mean we shut the doors to our schools and lock them? Does that mean we tear down our school buildings?

No. What it means is that schools as we typically think of them are not synonymous with 'education'. In fact, many schools today are not educating. That is why we need 'educology'—not only to understand the difference between schooling and educating, but also to open our minds about alternative and better ways of educating.

### ***What is 'educology'?***

'Educology' is 'knowledge' of 'education'. Sounds almost self-evident, but is profound—if we are precise about what is 'knowledge' and 'education'. The difference between schooling and 'education' is but one example of how 'educology' can make clearer what we are talking about when we lament problems we see in our schools, and what to do about these problems.

Without 'educology', educators and others will continue to talk past each other, much as in the biblical story about the Tower of Babel.<sup>1</sup> The language we typically use in talking about 'education' is imprecise, and so we literally often do not understand what

<sup>1</sup> I am using single quotes to identify terms in this chapter that are defined more precisely than common usage would typically indicate. I have created a growing and evolving website which provides a glossary of proper terms, definitions, and examples of 'educology' at: <http://educology.indiana.edu>. The intent of this Educology Website is similar to *Stedman's Medical Dictionary* (Stedman, 2006: defines medical terms) and *Terminologia Anatomica* (FCAT, 1998: categorizes proper anatomic terms) used in medical science, anatomy, and physiology.

each of us is talking about—because the same words refer to different things. For example, you are talking about a 'student', meaning she or he is a young person who attends a school or university, and I am thinking about a 'student' as being a person who intends to 'learn' under the guidance of another—she or he does not have to be in school or college, nor young, nor inside a building, nor guided by a state-licensed 'teacher' or a college professor. We may both use the same words, 'student', 'teacher', and 'learning', but we mean different things.

Unfortunately, we may think we are talking about the same thing, when in fact we are not. This kind of miscommunication and inconsistent use of terminology hinders advancement of 'knowledge' in the field of 'education'. You do a research study on 'student' 'learning', and find one result. I do a study on 'student' 'learning' and find a different result. Whose results should we believe? But we may not even be talking about comparable 'students' or comparable 'learning'. 'Learning' is yet another term that needs clarification.

It is as if you are studying cooked oatmeal with added sugar ('sucrose') and I am studying cornflakes with added 'high fructose syrup'. But we both call them sweetened cereals. This clarification is important because 'fructose' is 'metabolized' differently than 'glucose' in the human body. 'Fructose' is effectively a chronic 'toxin' that when metabolized rapidly in significant amounts repeatedly over time can lead to diseases that include Type 2 diabetes, atherosclerosis, and cancers.<sup>2</sup>

<sup>2</sup> See for example: Lustig (2009), *Sugar: The Bitter Truth* at <http://www.uctv.tv/shows/Sugar-The-Bitter-Truth-16717>; Taubes (2016), *The Case Against Sugar*; and McKinley, O'Loughlin and Bidle (2016), *Anatomy and Physiology: An Integrative Approach*.

It is as if in physics 'mass' and 'energy' meant different things to different people—a wide range of misconceptions. For example, some people think of 'mass' being associated with how big something is and how much it weighs. Not so, as it turns out, in the field of physics. 'Mass' is different from 'weight'. An astronaut living in the space station that orbits the earth 'weighs' nothing, and appears to just float in the air. Yet the same astronaut standing on a scale in the doctor's office on earth 'weighs' 130 'pounds', or about 59 'kilograms'. Her 'mass' has not appreciably changed. Just orbit the earth about 17,600 'miles' per 'hour', and we will 'weigh' nothing. And there are some new terms: 'pounds', 'kilograms', 'miles', 'hours' and the implied concepts of 'velocity', 'force', 'acceleration', and 'gravity'.

## **2. 'Universals' and theoretical 'signs'**

It is important that our terminology consists of 'universal classes'. 'Universal signs' are terms that signify phenomena which are not bound by time and place (see Appendix A and <http://educology.indiana.edu/universalSign.html>). For example, when we refer to 'adipose tissue cells' in physiology and anatomy, we are signifying a class of 'cells' in 'homo sapiens' in general, not just in Socrates' body about 2,500 years ago, now, or in humans in 5,000 A.D., whether here on earth or elsewhere.<sup>3</sup> As a non-example, to define 'student learning achievement' as scoring above 80 percent on the ISTEP test in Indiana in 2016 would *not* be a 'universal class', rather an 'individual class'.

'Signs' were defined by Peirce (1932):

<sup>3</sup> Appendix C provides a detailed example which illustrates the value of well-defined 'universal signs' in physiology and anatomy when discussing methods of decreasing 'mass' of 'fat' (i.e., 'triglycerides') in 'adipose tissue cells'.

A sign, or *representamen*, is something which stands to somebody for something in some respect or capacity.... every representamen being thus connected with three things, the ground, the object, and the interpretant. (2:228)

Peirce (1932) broadly classified 'signs' as 'iconic', 'indexical', and 'symbolic'. 'Signs' are discussed in more detail below.

How do we arrive at definitions of 'universal' classes? Steiner (1988) referred to Husserl's (1965) phenomenological method:

Rule 1. *Focus on the object.*

Rule 2. *Exclude the subjective.*

Rule 3. *Exclude indirect knowledge.*

Rule 4. *Exclude existence and the contingent.*

Rule 5. *Strive for complete disclosure.*

Rule 6. *Be analytic.* (p. 96)

Steiner (1988) used the phenomenological method to derive the definition of 'education'. For example, by use of Rule 4 above, schools as they exist in the U.S. in the 20<sup>th</sup> century are eliminated from the definition of the universal class, 'education'. Steiner (1988) further stated:

... one does not appeal to empirical observation nor does one simply regard a characteristic as essential. Instead with each characteristic, one asks whether without it the example could be considered an example of the same sort of thing as before. One

asks what characteristics an object must have in order to be recognized as an example of a certain kind of object. To illustrate, in my phenomenological inquiry into education, I asked whether a process could be education without having an active learner and teacher. Thus, I determined that a process must be a student-teaching one in order to be education. (p. 97)

### **3. What is 'education'?**

'Education' is defined as 'conducive learning'. 'Conducive learning' is both 'guided learning' and 'intended learning', which meets Steiner's (1988) criteria for what constitutes the 'universal class', 'education'. These essential relationships are further illustrated by Venn diagrams on the Educology Website: <http://educology.indiana.edu>. Figure 1 illustrates relationships among important concepts, in order to separate 'education' from all 'learning':

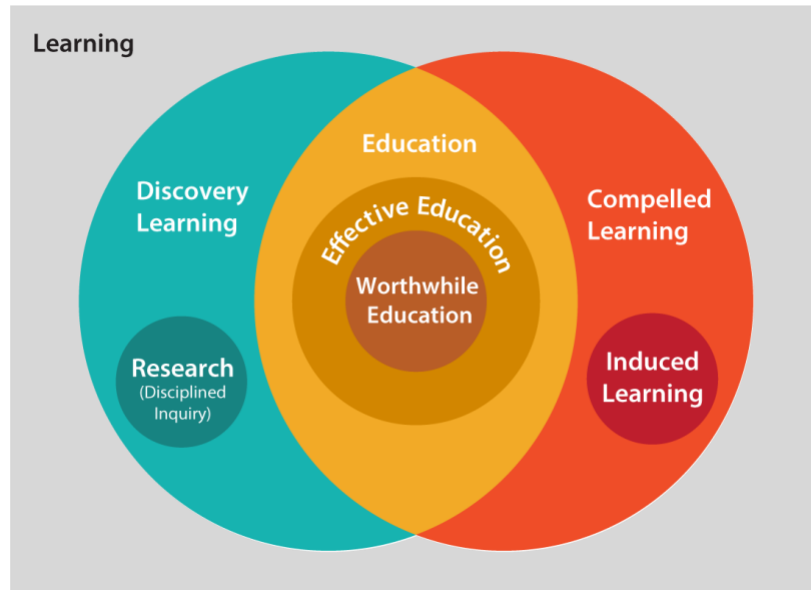


Figure 1. Venn diagram representation of kinds of 'learning' and 'education'

(graphic by Theodore Frick and Colin Gray).

Key concepts from which definitions of types of 'learning' are derived from this Venn diagram are further illustrated by specific shadings in Venn diagrams in Figures 1.1 – 1.13:

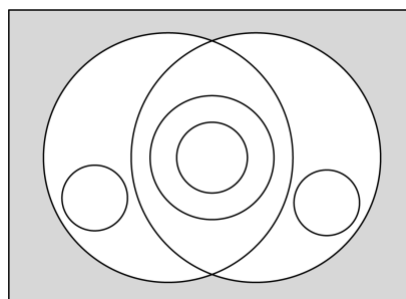


Figure 1.1. 'Accidental learning': neither 'intended learning' nor 'guided learning' (Type 1)

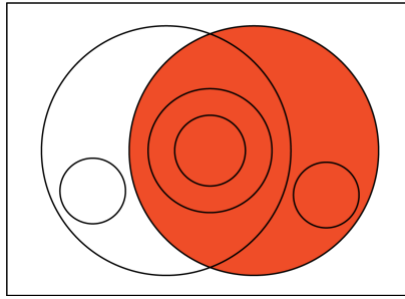


Figure 1.2. 'Guided learning' (Type 2)

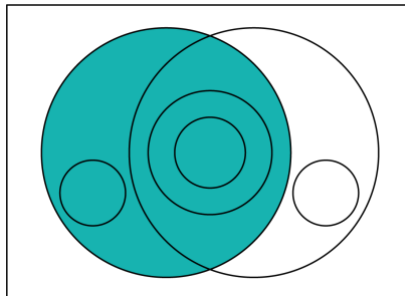


Figure 1.3. 'Intended learning' (Type 3)

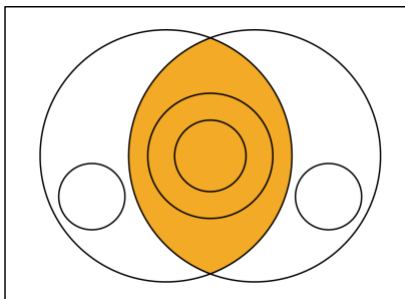


Figure 1.4. 'Conducive learning' ('education'): 'Intended learning' and 'guided learning' (Type 4)



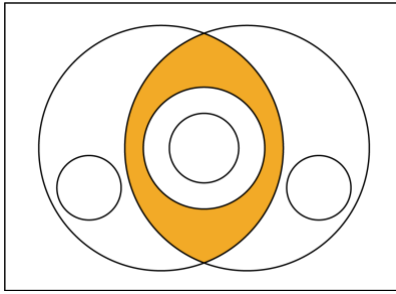


Figure 1.5. 'Ineffective education': neither 'instrumentally good' nor 'intrinsically good'  
(Type 5)

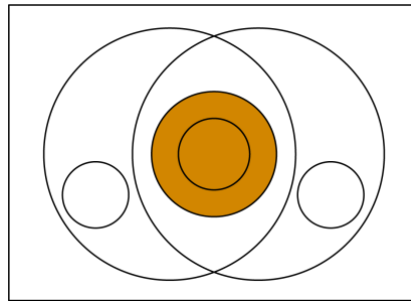


Figure 1.6. 'Effective education': 'instrumentally good' (Type 6)

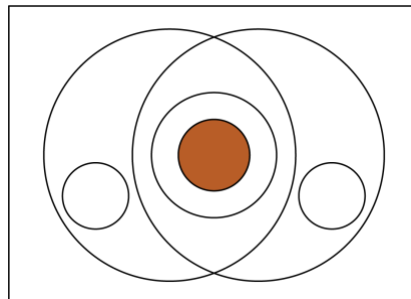


Figure 1.7. 'Worthwhile education': 'instrumentally good' and 'intrinsically good' (Type 7)

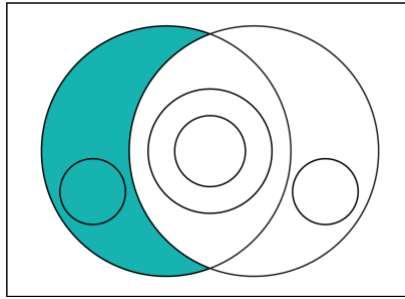


Figure 1.8. 'Discovery learning': 'intended learning' but 'unguided learning' (Type 8)

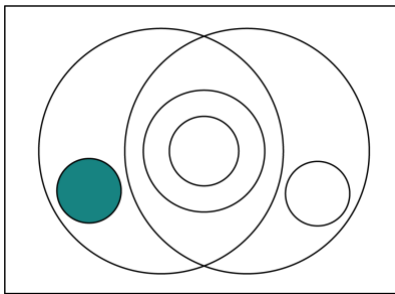


Figure 1.9. 'Disciplined inquiry' (research): 'discovery learning' that is regulated by criteria (Type 9)

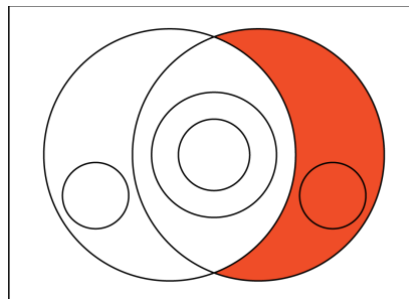


Figure 1.10. 'Compelled learning': 'guided learning' but not 'intended learning' (Type 10)

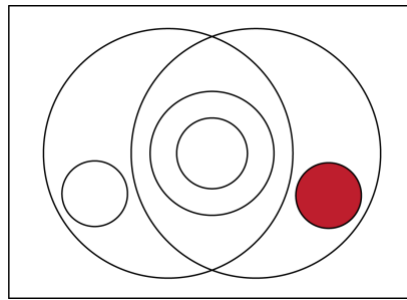


Figure 1.11. 'Induced learning': 'guided learning' but initially-unintended 'learning' (Type 11)

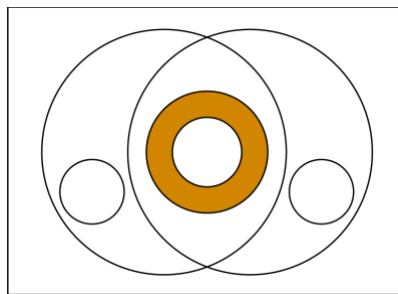


Figure 1.12. 'Effective bad education': 'instrumentally good' but not 'intrinsically good' (Type 12)

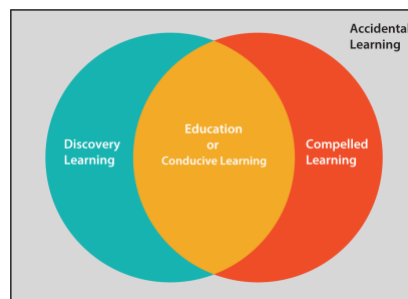


Figure 1.13. 'All learning': 'accidental learning' or 'discovery learning' or 'conduvive learning' or 'compelled learning'.

See Frick (2017) and the Educology Website at <http://educology.indiana.edu> for further details. What is important to note is that these terms are well-defined. In

particular, 'educology' is defined as recorded 'signs' of 'knowing' about 'intended learning' and 'guided learning'. 'Educology' is thus 'knowledge' of 'education'.

In the following sections, 'learning' is further explicated. Next discussed are 'knowledge, 'signs', 'education systems', and kinds of 'knowing'. Finally, 'worthwhile education' is discussed because, if we are to change 'education systems' for the better, it is imperative that such changes constitute 'worthwhile education'. We do not want 'effective bad education'.

#### **4. 'Learning' and intelligence revisited**

##### ***Experience, emotion, and formation of 'mental structures'***

When we 'learn' something new, we are able to connect it to what we already know. The desired outcome of successful 'learning' attempts is to form appropriate mental schema. Such 'mental structures' allow us to act intelligently as we go through life and carry out complex tasks (see van Merriënboer & Kirschner, 2013). Steiner (1988) defined 'learning' as "psychical development," which is the "formation of mental structures" (p. 40). This notion of 'learning' is further consistent with research in neurobiology. On the basis of a series of empirical studies, Kandel (2001) concluded that "... learning results from changes in the strength of synaptic connections between precisely connected cells [neuronal elements]" (p. 1032).

Steiner (1988) further characterized 'mental structures' as conative, cognitive or affective, as did Socrates, who identified 'will' or 'intent' as a part of mind (conative), as distinguished from the intellect (cognitive) and emotion (affective) (see *The Republic of*

*Plato*, Cornford, 1945). However, Greenspan and Benderly (1997) have noted that since the ancient Greek philosophers, the rational or cognitive aspect of mind has often been viewed as developing separately from emotion. They argue that this view has blinded us to the role of emotion in how we organize what we have learned: “In fact, emotions, not cognitive stimulation, serve as the mind’s primary architect” (p. 1). They identify the importance of emotion during human experience: “... each sensation ... also gives rise to an affect or emotion.... It is this *dual coding* of experience that is the key to understanding how emotions organize intellectual capacities ...” (p. 18).

Goleman (2011) articulates a somewhat different view, which he calls ‘emotional intelligence’. On the basis of neuropsychological brain studies he claims that, “When we have a thought it’s immediately valenced by these brain centers, positive or negative”. Goleman is referring to “... emotional centers in the midbrain, interacting with a specific area in the prefrontal cortex” (location 116). Goleman has been investigating whether emotional intelligence is a distinct human capability, in contrast to verbal or mathematical intelligence.

Rather than viewing emotional intelligence as a distinct human capability, Greenspan and Shanker (2004) have concluded that emotion is the architect of the mind. They considered emotion as central to how we organize our thinking. From the perspective of molecular biology, long-term memory is formed through synthesis of new proteins that alter synaptic strength among neuronal connections, resulting in structural change of the nervous system. “While the organism’s developmental program assures that the connections between the cells are invariant, it does not specify their precise strength.

Rather, *experience* alters the strength and effectiveness of these pre-existing chemical connections” (Kandel, 2001, p. 1032, italics added).

If emotion is indeed the architect of ‘mental structures’, as mounting evidence appears to support (see Greenspan & Shanker, 2004), then it follows that many students are likely to be developing ill-formed mental schema for the subject matter they are expected to ‘learn’ in school—‘mental structures’ which are weakened or disconnected from existing ‘mental structures’ due to feelings of meaninglessness, irrelevance, boredom and even disdain with respect to the content of their ‘education’ (see Yazzie-Mintz, 2007). Ideally, students should instead be developing ‘mental structures’ that are strengthened through real purpose in life and positive emotion. If so, then those positive feelings and the relevant purpose of ‘learning’ activities will facilitate organization of ‘mental structures’ that constitute long-term memory. Metaphorically speaking, once we have a solidly built house on a good foundation, then it is easier to add or remodel a room. We build on what is already there in terms of the existing structure.

To focus only on ‘student’ cognitive development at the expense of emotion will result in weaker or disconnected mental schema. Such schema will lack wholeness and hence would be poorly integrated into existing ‘mental structures’, much like an uninvited guest at a party who stands in the corner of the room and does not interact with other invited guests. If students do ‘learn’ (i.e., cognitive achievement), but they are indifferent or have negative feelings about the ‘learning’ experience, then such schema would be more vulnerable to forgetting due to lack of integration. In other words, such ‘student’ ‘mental

structures' are likely to be vulnerable—much as the proverbial house which is built on a poor foundation.

Dewey (1916) was very clear about the relation between the will and intellect:

Thinking, in other words, is the *intentional* endeavor to discover specific connections between something we do and the consequences which result... (p. 145, italics added)

Experience as trying involves change, but change is *meaningless* transition unless it is consciously connected with the return wave of consequences which flow from it. When an activity is continued into the undergoing of consequences, when the change made by action is reflected back into the change made in us, the mere flux is loaded with significance. We learn something. (p. 139, italics added)

Experience is primarily an active-passive affair; it is not primarily cognitive. But ... *the measure of the value* of the experience lies in the perception of relationships or continuities to which it leads up. It includes cognition in the degree in which it is cumulative or amounts to something, or has meaning. (p. 140, italics added)

Although Dewey did not explicitly realize the role of emotion in the creation of 'mental structures', he was aware of the lack of integration of real purpose in 'learning' in school and what is expected to be learned. He argued that purposeful experience was important in order to make 'student' 'learning' more meaningful. Even in his time, over a century ago, many students were bored with what appeared to be meaningless subject matter—as are many students in school today.

Intention (will) leads a learner to act—to try to do something. Actions result in experience—sensations that give rise to emotion and thinking. According to Greenspan and Benderly's theory, it is the dual coding of emotion and sensation during learner experience that results in changed 'mental structures'. Dewey also knew that the will was important, as well as emotion, in meaningful learning. Dewey apparently did not recognize just how important emotion is in organizing our memory through formation of 'mental structures'.

In summary, 'learning' is the formation of new or modified 'mental structures' that are connected to existing 'mental structure'. A person's intention and emotion organize that 'mental structure'. Metaphorically speaking, this affect creates the roads and streets that organize the layout of a growing city, which in turn determines where new buildings can be located. Those specific roadways that are constructed regulate how people can get from one place to another within the city, much as 'mental structures' allow us to remember and to think. For further details, see the Educology Website at: <http://educology.indiana.edu/learning.html>.

### ***The biological basis of memory as connected structure***

There is a biological basis for 'mental structures' as they are encoded through neural connections in the nervous system (Kandel, 1989; 2001; Squire & Kandel, 1999). The change of mind associated with meaningful 'learning' through experience that Dewey asserted is not just a figure of speech. Kandel (1989), a Nobel-prize winning neuroscientist, concludes from empirical evidence that:



Learning produces changes in neuronal architecture (p. 103)... Whereas short-term memory does not require the synthesis of new proteins ... the consolidation of long-term memory ... does require new protein synthesis (p. 109). ... [T]he long-term process differs from the short-term process in two important ways: one, the long-term process requires translation and transcription, and two, the long-term process is associated with growth in synaptic connections. (p. 115) .... Our evidence suggests that learning produces enduring changes in the structure and function of synapses... (p. 121)

Kandel recommends further study on the “... the *power of experience* in modifying brain function by altering synaptic strength...” (p. 123, italics added). Dewey likewise knew the power of experience in affecting our thinking and learning, especially in the context of purposeful activity that is meaningful to the learner. For further explication, see the Educology Website: <http://educology.indiana.edu/mentalStructure.html>.

### ***'Education' as the basis of cultural advancement***

Humans can 'learn' from experience through trial and error, as well as by accident. But 'learning' can be facilitated if guidance from another person is provided when 'mental structures' are formed during the 'learning' process. This is the essence of 'education': intended guided 'learning' (Steiner, 1988). One person is trying to 'learn' while another is providing guidance of that person's learning.

Such social interaction to guide learning by each new generation has been the major means by which human civilization and culture have advanced. While the size of the human brain has actually decreased by about 10 percent in the last 20,000 to 30,000 years

(Henneberg, 1998), human culture has advanced significantly—much more rapidly than changes in the human genome. Transmission of culture is the primary function of 'education', so each new generation can build on what has been learned by previous generations.

For example, 'learning' to start a fire by rubbing sticks together was at one time a significant kind of 'knowing how' that was very important for survival (e.g., for cooking, for warmth). This 'knowing how' was passed from generation to generation through 'education'. This 'knowing how' is not in our genes—it is not hereditary. Today, most people do not know how to do this, since they have not been taught. On the other hand, in modern times, many of us have learned how to strike a match to start a fire, and how to adjust the thermostat to the furnace in our home to keep warm. Invention of new tools is not in our genes either. While such invention originally was typically trial-and-error 'learning', once a tool was invented and found to be useful, then 'education' has been the primary means of passing on such 'knowing how' (part of culture) to subsequent generations.

Greenspan and Shanker (2004) explain further that:

... basic biological capacities are a "necessary" but not a "sufficient condition" for an individual learning to construct symbols and to think. That is, our biological potential for 'learning' from experience, which includes our rudimentary capacities to perceive, organize, and respond, is the critical substrate for the capacity to learn. The sufficient condition, however, involves a series of learning steps that are the basis for symbolic thinking. In human beings, however, even the tools of learning must be learned and

relearned by each new generation. These include the ability to attend, interact with others, engage in emotional and social signaling, construct complex patterns, organize information symbolically, and use symbols to think. (Kindle locations 83-88)

'Education' in the more general sense has been vital to survival and advancement of the human race. 'Education' is one of humanity's most enduring professions, and it is not just limited to those who are formally prepared as teachers in schools. Parents teach their children. Children teach children, and adults teach other adults and children. As the old African proverb states, "It takes a village to raise a child." Clearly, 'education' is a social endeavor, and has been vital to advancement of human civilization and culture.

## **5. 'Knowledge' and 'signs'**

### ***'Knowledge' as 'recorded knowing'***

'Knowledge' is taken to be '*recorded knowing*'. Such records are intersubjective, i.e., between persons, and they are preserved in some medium over a period of time. Steiner (1988) argues that:

First, knowing should be distinguished from knowledge. Knowing is a psychical state in which one has certitude about something and has a right to that certitude.... Knowledge, however, is recorded knowing; it is the body of expressed certitudes. (p. 5)

'Recorded knowing' can be preserved in a variety of media. At one time, cave paintings, stone and clay tablets, and papyrus were used. Nowadays, in addition to printed paper and books, we have video and audio recordings, photographs, animations, and

computerized games and simulations. We also have electronic storage devices to store records such as hard drives, flash memory, and the “cloud”, remote storage on devices which can be accessed over computer networks such as the Internet.

The record of knowing consists of '*signs*'. The '*signs*' are not the object of what is known, but rather the '*signs*' *represent* what is known. Charles Sanders Peirce spent much of his life attempting to develop a theory of '*signs*' (see Short, 2007). Peirce's theory evolved over his lifetime, which he never finished to his satisfaction. Peirce (1932) defined '*sign*' as follows:

A sign, or *representamen*, is something which stands to somebody for something in some respect or capacity.... every representamen being thus connected with three things, the ground, the object, and the interpretant (2:228).... The Sign can only represent the Object and tell about it. It cannot furnish acquaintance with or recognition of that Object; for that is what is meant in this volume by the Object of a Sign; namely, that with which it presupposes an acquaintance in order to convey some further information concerning it (2:231).

In discussing mind and nature, Bateson (1979) makes the same observation: “The map is not the territory, and the name is not the thing named” (p. 30). Bateson's '*territory*' and '*thing*' are Peirce's '*objects*' and the '*map*' and '*name*' are Peirce's '*signs*.' Bateson's '*map*' is a '*sign*' whose object is the territory being represented. The '*map*' is what Peirce refers to as an '*index*' in the sense that it is *affected by an existing object*—the actual territory that is represented by the '*map*'. While this distinction may seem obvious, it is

important to keep it in mind: a 'sign' is not the actual object itself, but *represents* the object. A satellite photograph of the territory would also be an 'indexical sign'.

Also noteworthy is Peirce's comment that the 'sign' "cannot furnish acquaintance with or recognition of that Object." Given the discussion below about 'knowing that one', it appears that direct apprehension of the object would appear to be an important condition to consider when discussing the meaning of 'signs' in communication. Otherwise, we might say that people do not really know what they are talking about, if they lack acquaintance or recognition—two kinds of 'knowing that one'.

### ***Iconic sign-object relation***

According to Peirce (1932):

An *Icon* is a sign which refers to the Object that it denotes merely by virtue of characters of its own, and which it possesses, just the same, whether any such Object actually exists or not (2:247)... That is, a quality that it has *qua* thing renders it fit to be a representamen. (2:276)

An illustration of a screened porch project in 1993 will hopefully clarify Peirce's sign-object relationships. Prior to building the screened porch that is represented by the photograph in Figure 3, Ted Frick imagined it in his mind, similar to the sketch of one of the panels in Figure 2. The actual screened porch did not exist yet prior to the summer of 1993, but the *idea* of it did in Ted's mind. The *object* was a mental image of a possible screen porch that Ted was thinking of building. He then drew some sketches for the design of the porch. These *sketches* were '*signs*' representing the object as imagined. In this case

the object of the 'sign' was a mental idea. These sketches representing the object were 'iconic signs' because they were a likeness that resembled the object (the idea) by virtue of their qualities.

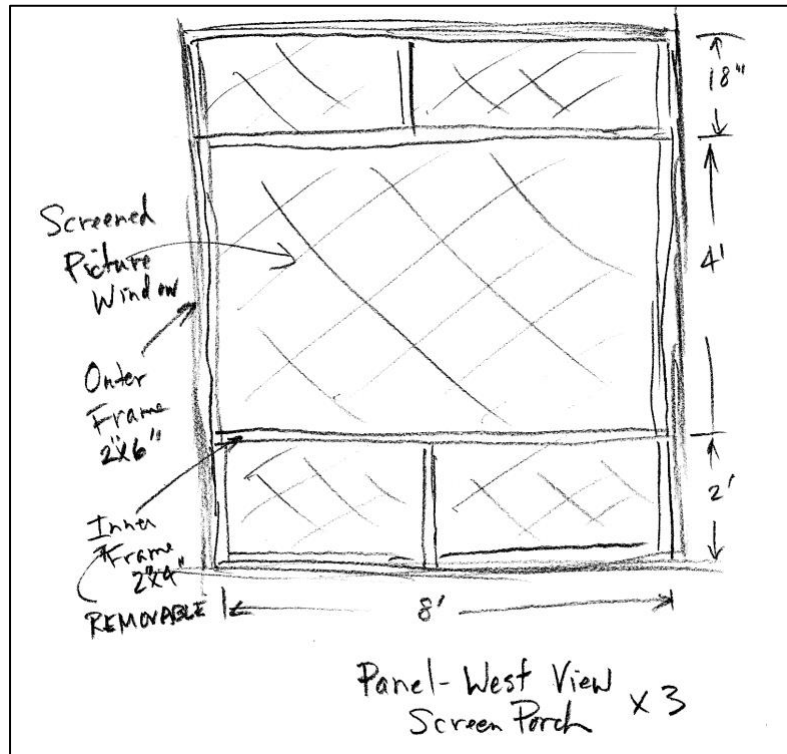


Figure 2. Sketch of a panel for the envisioned screened porch

Furthermore, Ted had previously noticed that most existing screen porches had structural elements that blocked people's view through the screen when they sat inside the porch. This gave rise to the image of a screened picture window in his design idea—through which one's view would not be obstructed by a structural element. This design feature was present in his sketches and also implemented when the porch was built.

Icons can also be representations of existing things, persons or phenomena. For example, political cartoons, such as those in the *Doonesbury* series by Gary Trudeau,

sometimes represent real people such as Presidents George W. Bush or Barack Obama, as well as fictional characters.

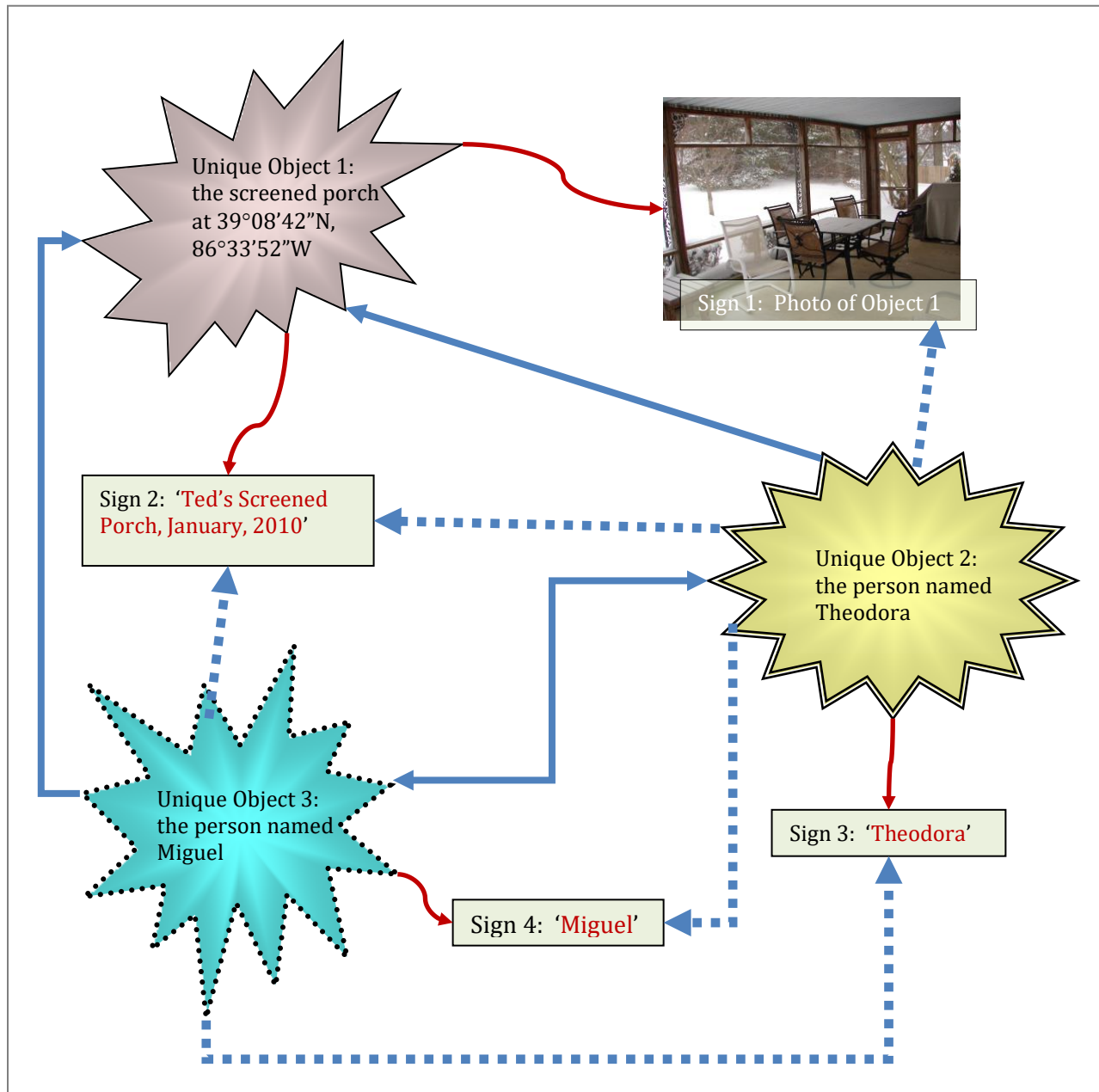


Figure 3. Illustration of relationships among objects, signs and persons.

### ***Indexical sign-object relation***

On the other hand, Peirce (1932) distinguished between an iconic and indexical relation between a 'sign' and its object:

An *Index* is a sign which refers to the Object that it denotes by virtue of being **really affected by that Object**.... In so far as the Index is affected by the Object, it necessarily has some Quality in common with the Object, and it is in respect to these that it refers to the Object (2:248, bolding added).... A genuine Index and its Object must be **existent individuals** (whether things or facts), and its immediate Interpretant must be of the same character. But since every individual must have characters, it follows that a genuine Index may contain ... an Icon as a constituent part of it (2:283, bolding added).

To be clear about this, consider the illustration in Figure 3. There are three unique objects—two of which are persons and the screened porch<sup>4</sup>—and four 'signs'. There are relations between these objects and 'signs'. 'Sign' 1 is an index, since the photograph (the 'sign') is clearly "affected by the object" and it has "some quality in common with the Object" (the screened-porch-that-Ted-built-in-1993). An index need not be restricted to an image. 'Sign' 2 also functions as an index, consisting of words describing the object ('Ted's screened porch, January 2010.'). Likewise, 'Signs' 3 and 4 are used to index unique, existent individuals ('Miguel' and 'Theodora' respectively).

<sup>4</sup> Obviously, the actual persons, Theodora and Miguel, and the actual screened porch are not in Figure 3, but are represented by unique star-shaped 'signs' to the reader (but let's leave you, the reader, as another interpretant, out of the picture for now).



Furthermore, Theodora recognizes Miguel, and Miguel recognizes Theodora, represented in Figure 3 by a solid blue line with arrowheads on each end. Theodora recognizes the screened porch, and so does Miguel. As interpretants, Miguel knows that 'Sign' 4 is connected with the unique person, Theodora; and Theodora knows that 'Sign' 3 is connected with the unique person, Miguel; and Theodora knows that 'Sign' 1 represents the unique Object 1, the screened-porch-built-by-Ted-in-1993.

However, the screened porch does not recognize either Miguel or Theodora, since the screened porch is not a person with a mind and is not self-aware or conscious as are Miguel and Theodora. Both Theodora and Miguel have had direct experiences with the unique object 1, which is the basis of their recognition. Their recognition is grounded. Their relationship with the screened porch has been immediate in their experience at some time previously. The screened porch depicted in Figure 3 and its 'signs' are shared between subjects (the persons Theodora and Miguel) and hence are *intersubjective*.

On the other hand, you, the reader, most likely have never physically visited nor directly experienced the unique screened porch that Ted built in 1993. Unless you have been there and have directly experienced it, you do not directly 'know that one'-screened-porch, although you may now know '*signs*' associated with that unique object. Your experience with this screened porch is mediated by 'signs'. Your experience is not immediate. Your experience of *that-one-screened-porch-built-by-Ted* is not authentic. It is not grounded. You may 'know that'-specific-fact—with respect to remembering the '*signs*' that have been associated with their objects by some other interpretant.

### ***Symbolic sign-object relation***

The third kind of relationship between an object and 'sign' is *symbolic*. According to Peirce (1932):

A *Symbol* is a sign which refers to the Object that it denotes by virtue of a law, usually an association of general ideas, which operates to cause the Symbol to be interpreted as referring to that Object. It is thus itself a general type or law, that is, is a Legisign. As such it acts through a Replica. Not only is it general itself, but the Object to which it refers is of a general nature. Now that which is general has its being in the instances which it will determine. There must, therefore, be existent instances of what the Symbol denotes... (2:249)

While an index helps to *identify* the unique object, a symbol is often taken to represent a class of objects (a generality, or a concept). When we state the proposition that "Miguel is a male," we are indicating via 'symbolic signs' that he is an instance of the 'male' class. Such a proposition is a specific fact, if it is warranted. If the proposition is unwarranted, then it may be fiction or speculation—i.e., a belief that is not confirmed through the method of science (see Peirce, 1877; Short, 2007). In this case, it is a specific fact. Rational minds can certify that the proposition is warranted, and hence it is a specific fact.

What may cause confusion is that when objects are represented by symbols that are not proper nouns, we are accustomed to use a symbol to instantiate the object as a member of a class. When we use the 'sign', 'screened porch,' this can represent the class of porches (a generality) or it can be part of a 'sign' that indexes the unique object, such as *the-*

*screened-porch-originally-built-by-Ted-in-1993-at-39°08'42"North-86°33'52"West-which-existed-until-July-2011.*

'Signs' as symbols are dependent on legisigns that constitute a culture's natural language. The terms, 'screened porch' or 'porch enclosed with window screen' could be characterized by different symbols from languages other than English, such as 'porche con ventanas con mosquitero' in Spanish, 'βεράντα κλεισμένη με τζαμαρία' in Greek, or 'трём ограден со прозорци' in Macedonian. When the relation between object and 'sign' are symbols, Peirce referred to such 'signs' as legisigns which act through replicas. Clearly, the symbolic 'signs' in Figure 3 could be expressed in different languages, even though the same individual unique objects are represented—e.g., Theodora's name could have been written in Greek, her native language: Θεοδώρα.

Symbols can also be used to represent generalities. Generalities are not bound by time and place. For example, consider the proposition, "All humans are mortal." First, what is being represented by the 'signs' that constitute the proposition is not an existent individual who is unique. The object is all the instances of the class—in this case, all human beings who have ever existed or will exist. The proposition further asserts that each and every one of these human beings has died or will die. This idea could also be expressed in many different natural languages. The language in which the proposition is expressed is arbitrary—i.e., the cultural legisigns. The idea represented by the proposition is not arbitrary. Whether the idea is warranted or not is another matter.

Thus, the type of 'sign' should not be conflated with the object it represents. Symbols can be used as indexes of existent individual objects; and so can icons. The types

of 'signs' are not mutually exclusive in that more than one kind can be used to represent any given object.

In summary, 'knowledge' is considered to be 'recorded knowing'. 'Recorded knowing' consists of 'signs' that represent objects of what is known by persons. 'Icons', 'indexes', and "symbols' can be used to represent objects of 'knowing that one', 'knowing how' and 'knowing that'. Kinds of knowing are discussed below in Section 7 and further illustrated in Appendix B.

In addition, 'signs' and their objects are relevant to the 'content' of 'education'. 'Content' is defined as 'signs' of objects and objects selected by a 'teacher' for 'student' 'learning'. See Appendix A. While a person can come to 'knowing that one' *without* 'signs', it is difficult to imagine—through 'education'—a way in which that person could come to 'knowing how' without exposure to 'indexical signs' (such as demonstration of the 'knowing how' by another person such as a 'teacher'). Coming to 'knowing that' would be difficult, if not impossible, without use of legisigns as a 'teacher' guides 'student' 'learning' of concepts, relations and criteria.

Thus, 'knowledge' and 'signs' are relevant to 'educology' itself, as well as to 'content' of 'education'.

## **6. What is an 'education system'?**

An 'education system' is defined as an 'intentional system' consisting of at least one 'teacher' and one 'student' in a 'context'. 'Context' is defined as the 'system environment' of 'teacher' and 'student' that contains 'content'. 'Intentional system' is further defined by

Thompson (2008a) at <http://educology.indiana.edu/intentionalSystem.html>, as well as 'system environment' at <http://educology.indiana.edu/systemEnvironment.html>. A 'teacher' is defined as a person who intends to guide another person's 'learning'. And a 'student' is a person who intends to 'learn' 'content' with a 'teacher'. See Appendix A.

Note that to be an 'education system':

- it does not have to be a formal school or a university system, which is just one way of organizing 'education', with a superintendent or president as leaders;
- 'teachers' do not need to be licensed and formally educated adults;
- 'students' are not restricted to those in school or universities, nor only to young persons;
- the 'context' does not need to be a school building or a campus;
- the 'content' does not need to be subject matter typically taught in schools and universities—e.g., math, science, history, biology, music, etc.

One of the early 'education systems' was Socrates leading his followers in Greece, as described in *The Republic of Plato*.

- Socrates did the overall leading (e.g., towards the goal of *thinking critically* about philosophy, and questioning of Sophist values);
- Socrates also did the guiding of 'student' 'learning' (e.g., through provocative statements and scenarios, by asking probing questions—later known as the Socratic Method of Teaching);
- his band of adult followers were the 'students';
- the 'context' consisted of various places in the city of Athens; and

- the 'content' was topics in philosophy (e.g., theory of 'universals', What is justice? What is the ideal city-state? Why should philosopher kings govern?).

Note that the definitions here are similar to Steiner's (1988) notion of 'education' as a "system consisting of subsystems of teacher (T), student (S), content (C), and context (X)" (p. 40). However, I am making a distinction between 'education' and 'education system' as described above.

Note further that 'context' includes 'content'. 'Context' is the 'system environment' in an 'education system'. Axiomatic Theories of Intentional Systems (ATIS) by Thompson (2006a, b; 2008a, b) is subsequently utilized for more precise definitions of 'system environment', 'intentional system', and numerous other systems properties. The 'context' could be anywhere, and need not be in a school or university, nor do 'teachers' and 'students' need to be in the same location. The 'context' could be digitally interconnected networks in real time (e.g., Zoom, Skype, FaceTime) or mediated through software applications created by teachers, instructional designers, and software engineers (e.g., simulations, serious games, tutorials, and quizzes).

## **7. Types of knowing**

### ***Overview of types of knowing***

There are three fundamental types of knowing: 1) 'knowing that one', 2) 'knowing how', and 3) 'knowing that' (Brown, 1970; Estep, 2006; Geach, 1964; Frick, 1997; Maccia, 1973, 1987; 1988; Scheffler, 1965). Clearly, these three classifications are *not exclusive* in the sense that two or more of them can occur at the same time within an individual. For

example, in Figure 4, the person knows his dog, Rover, as that-one (this particular unique dog), how to give Rover a bath, and Rover as an instance of the classification, 'dog' ('knowing that').

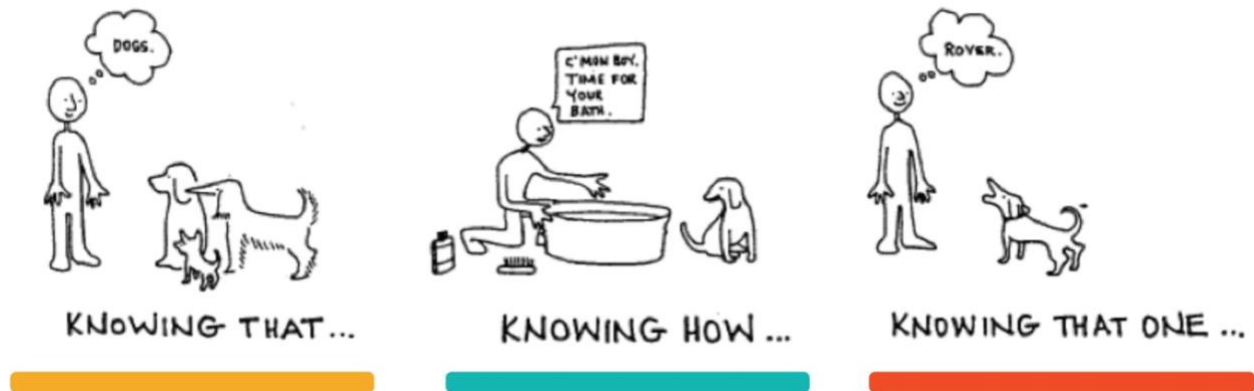


Figure 4. Basic kinds of knowing (drawings by Elizabeth Boling).

On the physiological level, 'mental structures' are encoded through neural connections in the nervous system (Kandel, 1989; 2001; Squire & Kandel, 1999). Steiner (1988) defined 'learning' as the "formation of 'mental structures'" (p. 40). Since one's knowing consists of 'mental structures' that are not directly observable by another person, it is necessary to identify indicators or 'signs' of such knowing. We can observe the actions of another person, which indicate what she or he knows. These may be evident from observing this person carry out some task, from examining a product resulting from this person's activity, and from examining 'signs' this person uses and creates (icons, indices and symbols) during that activity or in that product. Estep (2006) refers to such indicators as:

signs of intelligence ... [which] include the broader realm of three-dimensional patterns of sign-making, sign-exhibiting, and sign-disclosure of dynamic intentional doings... Three-dimensional signs such as signals and cues, include gestures (as with hands), but also full-body doings such as tasks or other performances.... These sign categories ... span all sensorimotor capacities, including visual, auditory, olfactory, gustatory, and somatosensory categories (including touching, moving, and proprioception). (pp. 38-39)

As an example, near the end of physicians' medical 'education', they become interns where they practice medicine with actual patients and their maladies. They are supervised and observed by teacher-physicians who are already licensed for practice, and who provide further coaching and feedback to these student-physicians-to-be. These physician-coaches can infer from observation whether or not their 'student' interns are making proper diagnoses, ordering appropriate medical tests, and carrying out appropriate treatments. In short, the test is a method by which a 'teacher' can unambiguously infer 'student' 'mental structures' from observable indicators under appropriate conditions. Tests are not restricted to answering questions or solving problems. Such exams are just one kind of indicator.

In discussing pedagogical epistemology, Maccia (1973) referred to tutorial conditions of knowing:

... knowing is viewed in light of tutorial requirements. Only those knowings to which a teacher has access, which a teacher can bring to a learner, and which a learner can communicate in some way to a 'teacher' are taken seriously. (p. 1)



There may be other kinds of 'student' knowing to which teachers have no access when observing and communicating with students. For example, Polanyi (1974) referred to tacit knowing, which essentially meant private, personal knowings not sharable with others as intersubjective 'signs'.

If teachers have no way to tell if students have achieved such unobservable kinds of knowing, then these kinds of knowing are excluded from 'educology'. This is why Maccia referred to *tutorial* conditions of knowing in further explication his pedagogical epistemology (e.g., Maccia, 1987, 1988). Note that his categories within 'knowing that', 'knowing that one', and 'knowing how' were refined between 1973 and 1988.

Kinds of knowing are based on Maccia's pedagogical epistemology, Estep's (2003, 2006) evidential arguments about natural intelligence (in particular, 'knowing how'), and Frick's (1997) discussion of issues in artificial intelligence. Nine kinds of knowing are outlined below:

1. **'Knowing that one'**: what are indicators of '*opinion*'—is it right?
  - 1.1. '*Recognitive*': select the unique *Q* from not-*Q* and not-*Q* from *Q*.
  - 1.2. '*Acquaintive*': identify relations determinate of the unique *Q*.
  - 1.3. '*Appreciative*': identify relations appropriate of the unique *Q*.
2. **'Knowing how'**: what are indicators of '*performance*'—is it effective?
  - 2.1. '*Protocolic*': take one path to goal; inflexible, duplicative doing.
  - 2.2. '*Adaptive*': take alternative paths to goal, choosing or combining paths based on specific conditions.
  - 2.3. '*Creative*': innovate or invent a new way to reach an existing or new goal.

3. **'Knowing that'**: what are indicators of *belief*—is it warranted by 'disciplined inquiry'?

3.1. *'Instantial'*: classification of objects of the same kind.

3.2. *'Relational'*: rational explanation of relationships between kinds of objects.

3.3. *'Criterial'*: rational judgment of kinds of objects and their relations according to a norm.

Norms for evaluating these kinds of knowing are indicated by the questions following each of the three major types. For 'knowing that one', *right opinion* is essential. For 'knowing how', conduct must be *effective*. For 'knowing that', beliefs must be *warranted by 'disciplined inquiry'*. Clearly, some opinions are not right, some actions are ineffective, and some beliefs are unwarranted. The task for us here is to sort these out.

Note that within each type of knowing, each higher level requires the lower level. 'Appreciative knowing' requires 'acquaintive knowing', and 'acquaintive knowing' requires 'recognitive knowing'. 'Creative knowing how' requires 'adaptive knowing how' that, in turn, requires 'protocolic knowing how'. 'Criterial knowing that' requires 'relational knowing that', and 'relational knowing that' requires 'instantial knowing that'. In other words, within each classification of knowing, the categories are progressively inclusive.

The types of knowing are not mutually exclusive. We can come to 'knowing that one', 'knowing how' and 'knowing that' with respect to some object. This is illustrated in Figure 4, where the dog Rover, is the object of 'knowing that one', 'knowing how', and 'knowing that'.

These kinds of knowing are not necessarily connected. For example, a person's 'knowing that' could be disconnected with his or her 'knowing how'. A person could come to 'knowing that one' without 'knowing how' or 'knowing that'.

For further details on kinds of 'knowing', see Appendix B. Moreover, 'signs' of 'knowing' about 'education' itself constitute nine kinds of 'educology'. See <http://educology.indiana.edu/typesOfEducology.html> for further explication.

## **8. 'Worthwhile education'**

'Worthwhile education' is defined as 'effective education' that is 'intrinsically good'. See <http://educology.indiana.edu/worthwhileEducation.html>. If we aim to improve 'education', we should seek worthwhile goals. In other words, what 'content' should 'students' 'learn'?

### ***Quality of 'content' for 'education'***

Not all recorded 'signs' qualify as 'knowledge'. There are many claims made that do not meet the criteria for 'recorded signs' of '*knowing*'. People can state opinions that are not supported by fact. People can make false claims—i.e., intentionally lie or deceive. For example, "fake news" has recently become a serious problem on the Internet, especially in social networks such as Facebook and Twitter. Such false claims can misinform and do real harm, such as adversely influence outcomes of elections of public officials in a democratic society.

Clearly, if we are to select the best of culture in 'education', we ought to help students 'learn' to value 'knowledge', and we ought to teach students to discriminate

among claims that are verifiable 'knowledge' claims compared with those that are not warranted. Students should 'learn' to be clear about what they do not know with certainty, and to suspend belief when claims are uncertain.

***'Knowing that one'***

Students should, whenever possible, be directly immersed in culture and come to know its elements without mediation. In other words, the student's experience should be direct and immediate. Students should come to trust their perceptions, and not be fooled by words of others who are intentionally deceptive or misleading. In other words, students should "see for themselves" in order to recognize, become acquainted and to appreciate what is unique. Students should also 'learn' to discern when another person's opinion is untrustworthy and should be dismissed.

For example, direct unmediated experience of an event is a requirement for witnesses who testify in a court of law. The legal system normally disallows 'hearsay evidence' in a trial. Hearsay evidence is when one forms their opinion based on someone else's report of their experience. The court is further concerned about the 'chain of evidence' with respect an artifact that is presented as evidence in a legal trial (to insure in as much as possible that it is authentic—e.g., the weapon used to commit the murder).

Legitimate news organizations normally want facts verified by at least two sources of information, and by reporters or witnesses who have had immediate experience of the unique event. When this kind of fact-checking is not done, it can lead to false reports (e.g., rumors, fake news). The problem is further exacerbated when one news organization relies on reports of another, and this other news organization has their facts wrong.

Misinformation is then spread, much like a rumor mill. A large number of people can be misled into holding wrong opinions based on false reports by presumably trustworthy sources (i.e., so-called authorities). People can also believe they have right opinion because many others hold the same opinion, when in fact they are all mistaken. At one time, most people believed that the earth was flat like a table top and at the center of the universe.

In modern schools, where students are largely sequestered inside of buildings for their formal 'education', direct experience of events in the world is more difficult to arrange. So-called "field trips" are rare because of the expense of transportation and challenges in providing 'student' safety while out in the "real world". After a while, it is easy to get lulled into believing that one has right opinions based solely on reports by others, whether they are textbooks, documentary movies or guest teachers.

Moreover, students may not get enough practice in seeing for themselves. The challenge is for students to be able to compare their own direct experiences with what is reported by others via 'signs' (icons, indexes and symbols). Students should 'learn' to discern when those other sources hold wrong opinion by comparing what those sources say to what a 'student' directly knows about that-one. Students ought to 'learn' how to do fact checking, and to gain confidence in dismissing shoddy or deceptive reporting by others. In other words, students ought to become good at detecting other people's ignorance and wrong opinions about what is unique. They ought to become good at questioning so-called authority. In other words, students should be become connoisseurs of authenticity of what is unique.

This task becomes especially challenging when investigating unique events of the past, where direct experience is no longer possible. This is the same challenge faced by historians. Students can nonetheless investigate reports by others. They should seek primary sources and be able to discern primary from secondary or tertiary sources of information. They should 'learn' to form opinions about unique events based on the coherence and integrity of representations in reports made by others, and to examine motives of those reporting (why they might want to intentionally distort the facts). If coherence and integrity are lacking, students should suspend belief and realize that they just do not know for certain. And a 'student' should always keep in mind that opinions can be wrong, which are formed on the basis of other people's inaccurate reports, and to realize that such opinions lack the greater certainty that the 'student' could achieve through direct, unmediated, careful observation for himself or herself.

### ***'Knowing how'***

'Signs' of 'knowing how' should represent worthwhile means to ends. Students should engage in *effective* and *ethical* conduct that contributes to the quality of life in society. In other words, students should engage in *worthwhile* conduct—which is both instrumentally and intrinsically valuable.

In TIE theory, Frick (2017) predicts that 'student' 'mental structures' will be stronger and less vulnerable to forgetting when they engage in authentic 'learning' tasks which will help them integrate 'knowing how', 'knowing that one' and 'knowing that' with their intentions and emotions. 'Learning' tasks are authentic if they are tasks that people actually do in the social system and culture in which teachers and students live.

Most authentic tasks that adults do in society would be beyond the capability of young learners. For example, we cannot expect a six-year old child to perform arthroscopic surgery. Thus, the challenge for educators is how to sequence such authentic tasks from simple to complex, starting with those which students are capable of 'learning' how-to-do, and building gradually towards those that adults do in the social system.

While educators can identify a set of core tasks that all students should 'learn' how to do, clearly some specialization will take place the further along a 'student' gets in his or her 'education'. Not everyone needs to 'learn' how to do arthroscopic surgery. As students advance, they will likely want to choose an area of specialization that will meet a need in society. Nonetheless, within specialized disciplines such as medicine, organic chemistry, computer science, anthropology, etc., whole tasks can be identified which are appropriate to those professions or disciplines and which are authentic.

Finally, we should not lose sight of three kinds of 'knowing how'. Students should have numerous opportunities to carry out authentic tasks that are not only 'protocolic', but also 'adaptive' and 'creative'. It is especially important in 'education' that students should be given repeated opportunities to invent and to be creative. This is a highly important capability for human survival and advancement of civilization and culture. While 'creative knowing how' cannot be taught directly, it can be encouraged and time can be made available for students to experiment, tinker, and invent. Creativity need not be restricted to the fine arts such as painting, drawing, writing poetry, or composing music. Practical arts are important as well. For example, invention of a way to increase crop yields in agriculture by controlling weeds without harmful pesticides and herbicides would benefit

many people. As a further example, writing computer software to solve a problem, or inventing a more efficient solar cell, can be very worthwhile. Devising new theory, refining and evaluating it can also be valuable result of 'creative knowing how'.

There have been numerous efforts to improve 'education systems' (see Mourshed, Chijioke & Barber, 2010) and some have been highly successful. However, raising 'student' achievement test scores in reading and mathematics will not in itself lead to a better economy, more jobs, or improvements in the quality of life. While 'learning' these basic skills is important, we also need to prepare students to develop 'mental structures' for 'creative knowing how'. 'Creative knowing how' should not get lost in the curriculum. We need all the help we can get in inventing solutions to real problems we face in the world— solutions which will truly improve the quality of life and will help advance human civilization and culture.

### ***'Knowing that'***

In addition to forming 'mental structures' for right opinions and worthwhile conduct, students should form 'mental structures' for generalizations that are warranted— i.e., we want students to come to hold beliefs that are warranted through 'disciplined inquiry'. This means that students need to 'learn' the symbols associated with classes of objects in order to correctly identify objects as to their type or kind.

### ***'Instantial knowing that'***

For example, in Figure 4, one should be able to classify the four-legged animals as 'dogs'. And the living beings illustrated in Figure 4 are 'mammals' not 'insects' or



'invertebrates.' Instantiation is the most basic kind of 'knowing that', sometimes referred to as knowing concepts.

In addition to widely used cultural 'signs' that are part of everyday language, certain scholarly disciplines have developed their own classifications and specific vocabulary. For example, what people commonly refer to as 'water' is more precisely defined in chemistry as 'molecules' of H<sub>2</sub>O, where each molecule consists of two 'atoms' of 'hydrogen' and one 'atom' of 'oxygen.'

As civilization progresses, 'knowledge' advances, and the more we know, new concepts are introduced as new theories are developed and tested. Older concepts and theories are rejected or replaced because better ones supersede them. For example, in the mid-nineteenth century, the spread of infectious disease was better understood after the obstetrician, Ignaz Semmelweis, observed that a greater percentage of healthy mothers had died from childbed fever who had been examined during labor by his medical students, when compared with mothers assisted solely by midwives. His students had often come directly from the dissecting room—where they had been working with cadavers of women who had died of the disease. He theorized that his students were somehow carrying the infection with them. After he ordered them to wash their hands in antiseptic solution before examining mothers during labor, the percentage of deaths from childbed fever dropped significantly (see Semmelweis, 2008). As another example, while Newton's Laws were adequate for explaining force among relatively large masses, they were found to be inadequate for explaining force at the atomic level. New theory was needed and was developed by physicists—e.g., quantum theory and the general theory of relativity.

*'Relational knowing that'*

Students should 'learn' relationships that are warranted by 'disciplined inquiry'. Another name for this is 'theoretical knowing'. Students should correctly understand each relation; they should be able to provide an argument that warrants the generalizability of the relation; and they ought to be able to explain the relevance and fruitfulness of the relation (see Maccia, cited in Frick, 1997, Table 1).

For example, humans learned long ago about the notion of gravity, in the sense that objects in high places will fall down unless they are opposed or held in place. 'Fall down' is a relationship between an object and the ground below. This is a predictable relationship. If one is up in a tree and lets go of the branch, then he or she will fall to the earth. This notion of 'falling down' was eventually formalized into a theory of 'gravity'. Isaac Newton identified concepts such as 'force,' 'mass,' 'velocity,' 'acceleration,' 'time,' 'distance' and their relationships.

For example, in classical mechanics 'momentum' is the 'mass' of an object, multiplied by its 'velocity'. Many people previously had learned through experience that if they threw a heavy rock at someone, it would hurt them more than if they threw a small lightweight pebble at the same speed. They also knew from experience that if they threw that same heavy rock at a faster speed, it would often hurt someone more than if thrown at a slower speed. Newton was able to formalize these relationships in his theory of gravity. His theory was also able to predict what would happen when dropping a pebble and a large rock from the same height and explained why both would accelerate at the same rate, reaching the ground at the same time. It could also predict orbits of planets around the sun

and the velocity necessary for an object such as the space shuttle to orbit the earth in the vacuum of outer space.

What is further significant is that theories can be tested (see Steiner, 1988). Truth of theoretical propositions can be evaluated. Not all theories are supported by sufficient evidence; and some theories are more adequate than others. Evidence can be brought to bear for warranting assertions. Scientists and philosophers make different kinds of arguments. The kinds of tests of theory that are acceptable are part of the discipline in a domain of inquiry. Students who 'learn' theoretical propositions should also 'learn' how those theories have been tested—in other words, what is the justification of the relationship. Verification and falsification are important concepts in development of theoretical knowing—i.e., knowing of relationships that are warranted by 'disciplined inquiry'.

*'Criterial knowing that'*

A criterion is a standard or norm by which some class of objects can be judged. A common example is that when checking baggage for a flight, the criterion is that each suitcase or bag must weigh no more than 50 pounds and that the dimensions of each bag must be within specified height, width and depth restrictions. The *justification* for these standards for maximum weight and dimensions of checked baggage is typically not made explicit, but presumably is determined by tolerances of their conveyor belt systems, baggage carts, and airplane cargo space. Also, the airline does not want to harm airline employees by requiring them lift too much weight.

According to Maccia (cited in Frick, 1997, p. 113), the person must not only correctly understand the criterion, but must also make a justificatory argument to warrant the credibility of the criterion, and must further be able to “demonstrate the relevancy and fruitfulness” of the criterion.

The general issue with a criterion is that other criteria are used to justify the initial criterion. But how are the further criteria justified? And how are the criteria for those further criteria justified? This could go on *ad infinitum*. One could appeal to an authority as a means of justification, but how do we know if the authority has adequate justification? One could cite empirical evidence as a means of justification, but the danger with this method is the ‘naturalistic fallacy’. Just because something occurs or exists does not justify that it is worthwhile. For example, it is a fact that murder occurs, but the fact that murder exists does not mean that murder is just.

‘Disciplined inquiry’ is required to justify a criterion if one is to avoid the naturalistic fallacy or appeal to authority. What constitutes adequate justification of beliefs is critical. Peirce (1877) described four methods by which humans fixate beliefs: tenacity, authority, agreeableness to reason, and science (i.e., ‘disciplined inquiry’).

In the ‘*method of tenacity*’, one literally holds onto his or her belief despite evidence to the contrary or lack of evidence to support it. For example, some people are resolute in their belief that drinking eight glasses of water a day will help them to lose weight. However, it turns out that this belief is myth. There is no scientific evidence in medical research to support this claim (Vreeman & Green, 2007). To remain steadfast in this belief is to use the ‘method of tenacity’.

When one holds a belief according to what people in a position of power or authority dictate or according to what doctrine says, he or she is using the '*method of authority*' to fixate belief. For example, to believe that global warming is occurring because former Vice-President Albert Gore said so, is to use the method of authority.

The third method Peirce referred to is the '*a priori method*' ('agreeableness to reason')—"it does not mean that which agrees with experience, but that which we find ourselves inclined to believe" (Peirce, 1877, p. 15). For example, to believe that people with larger brains are more intelligent, without evidence to support this assertion, would be to use the '*a priori method*'.

When one uses the '*method of science*', then '*disciplined inquiry*' is carried out in such a way that others can use that same method to see if the same conclusions would be reached. For example, in chemistry molecules of water are said to each consist of two atoms of hydrogen and one atom of oxygen (H<sub>2</sub>O). In Euclidean geometry, the claim is made that the sum of the interior angles of a triangle is 180 degrees. In medicine, the claim is made that people who smoke heavily are 5-10 times more likely to contract cancer later in their lives. In philosophy, Kant (1785) stated the proposition for moral behavior, known as the categorical imperative: "Act only according to that maxim whereby you can at the same time will that it should become a universal law" (p. 30). Each of these disciplines provides methods by which such claims can be examined and tested by others. When such tests are carried out, the same conclusions should be reached.

Peirce (1877) referred to science in the broad sense of knowing that is justified by methods that others can try themselves, not science in the narrow sense of biology or

physics. “The test of whether I am truly following the method is not an immediate appeal to my feelings or purposes, but, on the contrary itself involves the application of the method” (p. 20).

Steiner (1988) argues that this method of ‘disciplined inquiry’ can be used in justifying criteria. Claims about criteria can be tested. However, such tests do not and should not rely on empirical evidence as do science and praxiology. ‘Criterial knowing that’ relies ultimately on philosophical reasoning. That is, if one is willing to assume initial principles, and one is rational, then the justification of the criterion is a logical consequence of those initial principles. These principles concern what *ought to be*, not what is. Such principles are a matter of intrinsic value.

Consider for example the act of murder. Murder should not be justified on the basis of empirical evidence. Just because murder occurs does not mean that it is right. If we initially assume that we ought to treat others as we ourselves wish to be treated as a moral principle (the Golden Rule), and if we believe that it is wrong for others to murder us, then we must also conclude that it is wrong for others to be murdered. A person would be irrational to hold the Golden Rule as an initial principle, to hold that it is wrong for someone to murder him or her, and also believe that it would be right for others to be murdered. The person’s beliefs would be contradictory.

In summary, in ‘knowing that’, a person comes to hold beliefs that are warranted, and she or he can justify his or her beliefs. The justification should include an evidentiary argument that establishes the credibility of the belief and which demonstrates its relevance and fruitfulness.

'Truth' itself is a criterion by which to judge beliefs. Peirce argued that the method of science ('disciplined inquiry')—when used repeatedly over time by many individuals—warrants those beliefs:

To satisfy our doubts, therefore, it is necessary that a method should be found by which our beliefs may be determined by nothing human, but by some external permanency — by something upon which our thinking has no effect. Some mystics imagine that they have such a method in a private inspiration from on high. But that is only a form of the method of tenacity, in which the conception of truth as something public is not yet developed. Our external permanency would not be external, in our sense, if it was restricted in its influence to one individual. It must be something which affects, or might affect, every man. And, though these affections are necessarily as various as are individual conditions, yet the method must be such that the ultimate conclusion of every man shall be the same. Such is the method of science. (Peirce, 1934, 5:384)

Short (2007) notes that: "Here, science is used narrowly, for a form that inquiry normally takes, and a method of science is used broadly, for all the ways in which we might seek to subject belief to impersonal tests" (p. 330).

'Criterial knowing that' is not restricted to principles for judging human conduct such as the Golden Rule or to rational principles for judging beliefs such as those in 'disciplined inquiry'. Criteria are also relevant for judging 'knowing how'. For example, 'effectiveness' is a criterion that can be used to judge 'knowing how': Does the performance result in the desired outcome? For instance, if arthroscopic knee surgery is performed, does it work—i.e., does the patient recover the normal use of his or her knee after surgery?

Likewise, criteria are relevant for judging 'knowing that one'. For example, authenticity is a criterion for appreciative 'knowing that one' (see Maccia, 1987).

Finally, 'criterial knowing that' is an important educational objective that should not get lost as we attempt to improve our 'education systems' (see Mourshed, Chijioke & Barber, 2010). Critical thinking is needed for solving problems we face in the world. To think critically requires that one knows criteria and can justify them. Criteria are needed for choosing worthwhile solutions to problems.

## **9. Conclusion**

### ***Trial-and-error approaches to improving 'education' are risky and inefficient***

Educators who have been around several decades have seen widely touted changes come and go. In the past four decades, for example, some of the innovations have been referred to as: site-based management, constructivist classrooms, technology integration, school restructuring, systemic change, and re-inventing schools.

Despite such rhetoric, changes that have occurred in U.S. K-12 schools appear to be "tinkering around the edges." In 2017, for example, there may be more use of computer tablets, Chromebooks, and wi-fi networks in schools, more standardized achievement testing, more accountability for 'student' 'learning' achievement, less state funding for public schools, more tax dollars going to private charter schools, and increased regulation of schools by state and federal governments.



But, have any of these changes significantly improved K-12 'education'? While apparently well-intentioned state legislators and state departments of 'education' are mandating changes in K-12 'education', there are no guarantees of improving matters.

Worse, these changes may cause more harm than good. The stakes are very high. The consequences of mistakes can be devastating for our children and our future.

The following questions have not been adequately addressed:

- "Change what?"
- "Change how?" and
- "How do you know the change is likely to work?"

We must know what to change in order to know how. Without knowing what to change, the "how" is irrelevant (Frick, Thompson & Koh, 2006). We must know whether the change is likely to accomplish the goal and that the change will not have negative, unintended effects.

For example, attempts to hold teachers accountable for 'student' achievement not under their control may drive the best teachers to leave the profession, due to frustration with such working conditions. It may also discourage potentially good teachers from entering the profession. Moreover, the best students might leave the public schools to attend private schools, if their parents can afford it. This would leave public schools in possibly worse straits, with the least capable teachers and lowest achieving students remaining, and less money from public tax dollars to support them. Then what?

***Paradigm change for improving 'education' requires sound 'knowledge'***

Some scholars argue that an entire paradigm change is needed in 'education'. For example, Reigeluth & Karnopp (2013) have promoted a vision and strategies to get there. These include significant curriculum expansion, individualized learner-centered instruction, and attainment-based evaluation of learning—that contrasts with existing time- and age-based structures for moving 'student' groups through lock-step grade levels. As another example, Duffy (2009) is promoting systemic change efforts.

But do we know how well such new paradigms will work? This does not mean that a new 'education system' that is learner-centered and attainment-based is not worthwhile. Nor does it mean that changes to expand and revamp curriculum in school are not needed. It just means that we lack sound 'knowledge' to predict outcomes of new designs of 'education systems'.

***Why sound 'knowledge' of 'education' is needed***

As an analogy, consider an old bridge that is failing—it is structurally weak and is impeding the flow of traffic. If the bridge is not fixed, it will collapse and vehicles will plunge into the river. When engineers design a new bridge, they utilize adequate scientific theories. No one in modern times would consider designing a new bridge by trial and error. Nor would they let politicians try to do it.

Yet, in 'education' we are essentially proceeding by trial and error in attempts to improve 'education'—whether tinkering around the edges or by creating new

paradigms. We lack sound 'knowledge' to make reasonable predictions whether or not the proposed remedies will fix the problems in 'education' we face.

***Disciplines require precise language***

In disciplines where 'knowledge' has significantly advanced, there has been careful development of terminology so that researchers know what each other is actually talking about. For example, in physics the concepts of 'atoms' and 'molecules' are clearly defined. Each 'atom' has a particular combination subatomic elements called 'electrons', 'protons', and zero or more 'neutrons'. For example, in chemistry a 'molecule' of 'water' is comprised of two 'hydrogen' atoms and one 'oxygen' atom. A 'hydrogen' atom consists of one electron and one proton. A stable 'oxygen' atom contains eight each of electrons, protons and neutrons (see "Properties of water," n.d.).

As another example, it was not that long ago that the field of medicine was not a discipline. There was no medical science, as there now is. At one time, physicians would prescribe bloodletting to treat all kinds of disease, which turned out to be an ineffective practice and has been largely abandoned ("Bloodletting," n.d.). Many people were harmed by such ignorance.

Medicine advanced, in part, because researchers in the field became more disciplined in their inquiry. Terms are now precisely defined in medicine. 'Osteoarthritis' does not mean whatever people want it to mean. 'Osteoarthritis' is the medical term for a particular disease precisely described. Researchers and practitioners in the field of medicine have agreed on what this term means. Thus, when treatments of this particular disease are investigated, competent medical professionals know what they are talking

about. See Appendix C for a further example of the benefit of precisely defined terms for addressing 'obesity' through changes in diet.

### ***The need for precise language in 'educology'***

In the field of 'education', such precise terminology has not been developed. Steiner (1977, 1986, 1988) has long argued that such terminology is sorely needed for the field to advance, and has proposed the term, 'educology' to mean 'knowledge' of 'education'.

Basic terms of 'educology' have been defined: 'learning', 'knowing', 'signs', 'education system', 'teaching-studenting processes', 'teaching-studenting structures' and many others. The definitions are available to all at the Educology Website at: <http://educology.indiana.edu/glossary.html>.

A standard vocabulary will lead to advances in 'educology' that, in turn, will help improve 'education'—that is, develop 'worthwhile education' for everyone. One example that has benefited from this standard vocabulary is TIE theory (Frick, 2017). The theory of 'totally integrated education' (TIE) uses the terminology and definitions from 'educology' as explicated here. TIE theory predicts that 'student' 'mental structures' will be stronger and less vulnerable to disconnection when 'learning' activities help students to integrate 'knowing that one', 'knowing how', and 'knowing that' through authentic tasks (see <http://educology.indiana.edu/integratedLearning.html>).

The current chapter and the Educology Website serve as a beginning. We can talk, plan, conduct research, and think more constructively and clearly with the concepts of 'educology'.

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## **10. References**

- Bailor, J. (2015). *The calorie myth*. New York, NY: HarperWave.
- Bateson, G. (1979). *Mind and nature*. New York, NY: E. P. Dutton.
- Bloodletting (n.d.). In *Wikipedia*. Retrieved February 1, 2015 from: <http://en.wikipedia.org/wiki/Bloodletting>
- Bricklin, D. (2014). VisiCalc: Information from its creators, Dan Bricklin and Bob Frankston. Retrieved March 5, 2015 from: <http://www.bricklin.com/visicalc.htm>
- Brown, D. G. (1970). Knowing how and knowing that, what. In G. Pitcher and O. Wood (Eds.), *Ryle: A Collection of critical essays* (pp. 213-248). Garden City, NY: Doubleday.
- Cornford, F. M. (translator, 1945). *The Republic of Plato*. New York, NY: Oxford University Press.
- Dewey, J. (1916). *Democracy and education*. New York, NY: The Free Press.

Duffy, F. (2009, Ed.). The Scarecrow Education Series on Leading School Improvement. Retrieved February 1, 2015 from: <http://www.thefmduffygroup.com/publications/series.html>

Eades, M. R. & Eades, M.D. (1996). *Protein power*. New York, NY: Bantam Books.

Educology Website (2017). *Knowledge of education*. Retrieved January 27, 2017 from: <http://educology.indiana.edu>

Estep, M. (2003). *A theory of immediate awareness: Self-organization and adaptation in natural intelligence*. Boston, MA: Kluwer Academic Publishers.

Estep, M. (2006). *Self-organizing natural intelligence: Issues of knowing, meaning and complexity*. Dordrecht, The Netherlands: Springer.

Federative Committee on Anatomical Terminology (1998). *Terminologia anatomica: International anatomical terminology*. Stuttgart, Germany: Thieme.

Frick, T. W. (1997). Artificially intelligent tutoring systems: What computers can and can't know. *Journal of Educational Computing Research*, 16(2), 107-124.

Frick, T. W. (2017). The theory of totally integrated education: TIE. In J. M. Spector, B. B. Lockee, and M. D. Childress (Oversight Eds.), *Learning, Design, and Technology: An International Compendium of Theory, Research, Practice and Policy* (Vol. 1): *Learning theory and the learning sciences* (J. Elen, Vol. ed.).

Frick, T., Thompson, K., & Koh, J. (2006). Predicting education system outcomes: A scientific approach. In M. Simonson (Ed.), *Proceedings of the Association for Educational Communication and Technology*, Dallas, TX.

Geach, P. (1964). *Mental acts*. New York, NY: The Humanistic Press.

Goleman, D. (2011). *The brain and emotional intelligence: New insights* (Kindle Ed.). Northhampton, MA: More Than Sound LLC.

Greenspan, S. I. & Benderly, B. L. (1997). *The growth of the mind and the endangered origins of intelligence*. Reading, MA: Addison-Wesley.

Greenspan, S. I. & Shanker, S. G. (2004). *The first idea: How symbols, language, and intelligence evolved from our primate ancestors to modern humans*. Cambridge, MA: Da Capo Press (Kindle edition).

Henneberg, M. (1998). Evolution of the human brain: Is bigger better? *Clinical and Experimental Pharmacology and Physiology*, 25(9), 745-749.

Husserl, E. (1965). *Phenomenology and the crisis of philosophy* (translated by Q. Lauer). New York, NY: HarperCollins Torchbook.

Kandel, E. R. (1989). Genes, nerve cells, and the remembrance of things past. *Journal of Neuropsychiatry*, 1(2), 103-125.

Kandel, E. R. (2001). The molecular biology of memory storage: A dialogue between genes and synapses. *Science*, 294, 1030-1038.

Kant, I. (1785). *Grounding for the metaphysics of morals* (3<sup>rd</sup> ed., translated by J. W. Ellington, 1993). Indianapolis, IN: Hackett Publishing.

Lustig, R. (2009). *Sugar: The bitter truth*. University of California TV. Retrieved March 27, 2017 from <http://www.uctv.tv/shows/Sugar-The-Bitter-Truth-16717>

Maccia, E. Steiner. (1964). Logic of education and of educatology: Dimensions of philosophy of education. Proceedings of the Twentieth Annual the Philosophy of Education Society.

Maccia, G. S. (1986). Right opinion and Peirce's theory of signs. Paper presented at the Semiotic Studies Faculty Seminar. Retrieved January, 27, 2017 from: [http://educology.indiana.edu/Maccia/RightOpinionAndPeircesTheoryOfSigns\\_GSMaccia1987.pdf](http://educology.indiana.edu/Maccia/RightOpinionAndPeircesTheoryOfSigns_GSMaccia1987.pdf)

Maccia, G. S. (1986). Right opinion and Peirce's theory of signs. Paper presented at the Semiotic Studies Faculty Seminar. Retrieved from: [http://educology.indiana.edu/Maccia/RightOpinionAndPeirce'sTheoryOfSigns\\_GSMaccia1987.pdf](http://educology.indiana.edu/Maccia/RightOpinionAndPeirce'sTheoryOfSigns_GSMaccia1987.pdf)

Maccia, G. S. (1987). Genetic epistemology of intelligent natural systems. *Systems Research*, 4(3), 213-218. Retrieved January, 27, 2017 from: [http://educology.indiana.edu/Maccia/Correspondence\\_GeneticEpistemologyOfIntelligentNaturalSystems1987.pdf](http://educology.indiana.edu/Maccia/Correspondence_GeneticEpistemologyOfIntelligentNaturalSystems1987.pdf)

Maccia, G. S. (1988). Genetic epistemology of intelligent natural systems: Propositional, procedural and performative intelligence. Paper presented at Hangzhou University, China. Retrieved January, 27, 2017 from: [http://educology.indiana.edu/Maccia/GeneticEpistemologyOfIntelligentSystems\\_propositionalProceduralPerformativeIntelligence1988.pdf](http://educology.indiana.edu/Maccia/GeneticEpistemologyOfIntelligentSystems_propositionalProceduralPerformativeIntelligence1988.pdf)

McKinley, M. P., O'Loughlin, V. D. & Bidle, T. S. (2016). *Anatomy & Physiology: An integrative approach* (2<sup>nd</sup> Ed.). New York, NY: McGraw-Hill Education.

Molenda, M., & Rice, J.M. (1979). Simulation review: The Diffusion Simulation Game. Produced and distributed by the University Consortium for Instructional Development and Technology (UCIDT). *Simulation and Games*, 10(4), 459-467.



Mourshed, M., Chijioke, C. & Barber, M. (2010). *How the worlds most improved school systems keep getting better*. London: McKinsey & Co. Retrieved from: [http://ssomckinsey.darbyfilms.com/reports/schools/How-the-Worlds-Most-Improved-School-Systems-Keep-Getting-Better\\_Download-version\\_Final.pdf](http://ssomckinsey.darbyfilms.com/reports/schools/How-the-Worlds-Most-Improved-School-Systems-Keep-Getting-Better_Download-version_Final.pdf)

National Center for Health Statistics (2015). Prevalence of Obesity Among Adults and Youth: United States, 2011–2014. Centers for Disease Control and Prevention. Retrieved March 29, 2015 from: <https://www.cdc.gov/nchs/products/databriefs/db219.htm>

Peirce, C. S. (1877). The fixation of belief. In J. Buchler (Ed.), *The philosophic writings of Peirce*. New York: Dover Publications, 1955, 5-22.

Peirce, C. S. (1931). *Collected papers, Vol. I, Principles of philosophy* (C. Hartshorne & P. Weiss, Eds.). Cambridge, MA: Harvard University Press.

Peirce, C. S. (1932). *Collected papers, Vol. II, Elements of logic* (C. Hartshorne & P. Weiss, Eds.). Cambridge, MA: Harvard University Press.

Peirce, C. S. (1934). *Collected papers, Vol. V, Pragmatism and pragmaticism* (C. Hartshorne & P. Weiss, Eds.). Cambridge, MA: Harvard University Press.

Polyani, M. (1962). *Personal knowledge: Towards a post-critical philosophy*. Chicago, IL: University of Chicago Press.

Reigeluth, C. M. & Karnopp, J. R. (2013). *Reinventing schools: Its time to break the mold*. Lanham, MD: Roman and Littlefield Education.

Ryle, G. (1959). *The concept of mind*. New York, NY: Barnes and Noble.

Scheffler, I. (1965). *Conditions of knowledge*. Glenview, IL: Scott-Foresman.

Semmelweis, I. P. (2008). In *Encyclopædia Britannica*. Retrieved from Encyclopædia Britannica Online: <http://search.eb.com/eb/article-9066723>

Short, T. L. (2007). *Peirce's theory of signs*. New York, NY: Cambridge University Press.

Squire, L. R. & Kandel, E. R. (1999). *Memory: From mind to molecules*. New York, NY: Henry Holt and Co.

Stedman, T. L. (2006). *Stedman's medical dictionary* (28<sup>th</sup> Ed.). Baltimore, MD: Lippincott, Williams & Wilkins.

Steiner, E. (1977). Educology: Its origin and future. ERIC document No. ED141201.

Steiner, E. (1986). Crisis in educology. In J. E. Christensen (Ed.), *Educology* 86. Proceedings of a Conference on Educational Research and Development with an Educational Perspective, at Australian National University, Canberra, July 10-12 (pp. 221-227). Sydney, Australia: Educology Research Associates.

Steiner, E. (1988). *Methodology of theory building*. Sydney, Australia: Educology Research Associates.

Steiner, E. (2009). Ethical theory (Lecture notes). Retrieved from <https://www.indiana.edu/~tedfrick/steiner/Ethical%20Theory.pdf>

Taubes, G. (2016). *The case against sugar*. New York, NY: Alfred A. Knopf.

Thompson, K. R. (2006a). "General system" defined for predictive technologies of A-GSBT (Axiomatic General Systems Behavioral Theory). *Scientific Inquiry Journal*, 7(1), 1-11.

Thompson, K. R. (2006b). Axiomatic theories of intentional systems: Methodology of theory construction. *Scientific Inquiry Journal*, 7(1), 13-24.

Thompson, K. R. (2008a). ATIS glossary. Retrieved January, 27, 2017 from <http://www.indiana.edu/~aptac/glossary/>

Thompson, K. R. (2008b). *ATIS graph theory*. Columbus, OH: Systems Predictive Technologies. Retrieved from: <https://www.indiana.edu/~aptfrick/overview/reports/11ATISgraphtheory.pdf>

van Merriënboer, J. J. & Kirschner, P.A. (2013). *Ten steps to complex learning: A systematic approach to four-component instructional design*. New York, NY: Routledge.

Vreeman, R. & Greene, G. (2007). Medical myths even doctors believe. *British Medical Journal*, 335(7633), 1288-1289.

Yazzie-Mintz, E. (2007). Voices of students on engagement: A report on the 2006 high school survey of student engagement. Retrieved January, 27, 2017 from <http://www.eric.ed.gov/PDFS/ED495758.pdf>

## **11. Appendix A: Defined and undefined terms in 'educology'**

### ***Definitions of basic terms***

In order to explicate theory, it is necessary to define terms. Steiner (1988) states it this way:

... when one sets forth the terms of the theory and their definitions, descriptive metaphysics is presented.... Descriptive metaphysics is a division of the phenomena which are the object of theorizing—the system—so that a set of descriptors characterizing the system's properties emerges. To do this, the metaphysician must

provide a set of class terms for characterizing each and every component of the system.... Therefore, classification is basic to descriptive metaphysics.

However, classification always involves definition. A class term denotes all the particulars to which the term is applicable (the extension of the term) and connotes the characteristics that a particular must have in order for the term to be applicable to it (the intension of the term). (Steiner, 1988, p. 64)

Steiner provides criteria for evaluating descriptive theory: exactness, exclusivity, exhaustiveness, external coherence, extendibility, equivalence, chaining and substitution (pp. 64-74). Descriptive theory is necessary for building a foundation before explanatory theory can be explicated.

Fundamental to 'educology' are the following defined terms ('=Df ' is read as 'is defined as')<sup>5</sup>:

- '*Mental structures*' =Df '*affect-relations*'<sup>6</sup> which constitute intelligence<sup>7</sup>
- '*Learning*' =Df increasing of '*complexity*' of a person's "mental structure" (for Types 1 – 12)
- '*Learner*' =Df person whose volition is 'learning'
- '*Forgetting*' =Df decreasing of '*complexity*' of a person's 'mental structure'

<sup>5</sup> These and other terms are defined at <http://educology.indiana.edu>. This website provides definitions of these terms and more. It is easier to follow the chains of definitions on the website by clicking on the hyperlinks.

<sup>6</sup> Words which are green colored are defined elsewhere by Thompson (2008). See <http://www.indiana.edu/~aptac/glossary/>. These terms, defined in Axiomatic Theories of Intentional Systems (ATIS) can also be viewed at <http://educology.indiana.edu>.

<sup>7</sup> 'mental structures' can be formed for right and wrong opinions, for effective, ineffective, ethical and unethical conduct, and for true or false beliefs.

I have been discussing 'mental structure' above, and now I must be more precise. I take some definitions here from general system theory, and in particular, Axiomatic Theories of Intentional Systems (Thompson, 2006a, b; 2008a, b). 'Affect-relations' are the connections among components of a system, and 'complexity' is the number of connections. Thus, 'learning' is defined as *increasing* the number of connections in a one's 'mental structure'. This is consistent with what Kandel (1989) has concluded on a biological level, claiming that long-term memory is "associated with growth in synaptic connections [among neurons]" (p. 115), and that "learning produces enduring changes in structure and function of synapses" (p. 121).

The biological explanation of changes in the human nervous system is not part of 'educology'. 'Educology' asserts that humans form 'mental structures' as they 'learn'. To use Steiner's criterion, there is *external coherence*. This definition of 'learning' in 'educology' has external coherence with neurobiological 'knowledge'.

### ***Undefined terms***

Some terms in a theory must remain undefined (Steiner, 1988). Definitions could go on *ad infinitum* if there are no primitive terms. This is to avoid circularity in definitions, as well as infinite regress. Undefined terms follow: *intelligence, think, feel, intend, believe, perceive, guide, person, good, object (thing), course of action (conduct), end (goal)*.

### ***More definitions of terms in 'educology'***

The domain of human 'learning' is shown as a Venn diagram in Figure 1, which illustrates defined terms that include 'intended learning', 'guided learning', 'education',

'effective education' and 'worthwhile education'. Figures 1.1 through 1.13 illustrate via shadings in the Venn diagram how these terms are related but yet distinct.

- '*Accidental learning*' =<sub>Df</sub> 'learning' which is neither guided nor intended (see Figure 1.1)
- '*Discovery learning*' =<sub>Df</sub> 'learning' which is intended but unguided (see Figure 1.8)
- '*Compelled learning*' =<sub>Df</sub> 'learning' which is not intended but guided (see Figure 1.10)
- '*Conducive learning*' =<sub>Df</sub> '*education*' =<sub>Df</sub> 'learning' which is both intended and guided (see Figure 1.4)
- '*Student*' =<sub>Df</sub> a person who intends to 'learn' 'content' with a 'teacher'
- '*Teacher*' =<sub>Df</sub> a person who intends to guide another person's 'learning'
- '*Teaching*' =<sub>Df</sub> a 'teacher' guiding another person's 'learning' (see Figure 1.2)
- '*Sign*' =<sub>Df</sub> *representamen* =<sub>Df</sub> "something which stands to somebody for something in some respect or capacity.... every representamen being thus connected with three things, the ground, the object, and the interpretant" (see Peirce, 1932, 2.228)
  - '*Interpretant*' =<sub>Df</sub> a 'sign' derived by a person as a mental construct that is a representamen of the equivalent external 'sign', which relates to an object
- '*Content*' =<sub>Df</sub> objects and 'signs' of objects selected for 'student' 'learning'

- 'Context' =<sub>Df</sub> 'system environment' of 'teacher' and 'student' that contains 'content'
- 'Education system' =<sub>Df</sub> 'intentional system' consisting of at least one 'teacher' and one 'student' in a 'context'
- 'Knowing' =<sub>Df</sub> 'mental structures' which consist of warranted beliefs<sup>8</sup>, right opinions, and capabilities for performance (See Figure 4)<sup>9</sup>
  - 'Knowing that one': 'mental structures' for right opinion
    - 'Recognitive': select the unique  $Q$ <sup>10</sup> from not- $Q$  and not- $Q$  from  $Q$ .
    - 'Acquaintive': identify relations determinate of the unique  $Q$ .
    - 'Appreciative': identify relations appropriate of the unique  $Q$ .
  - 'Knowing how': 'mental structures' for effective performance
    - 'Protocolic': take one path to goal.
    - 'Adaptive': take alternative paths to goal, choosing or combining paths based on specific conditions.
    - 'Creative': innovate or invent a new way to reach an existing or new goal.

<sup>8</sup> C. S. Peirce (1877) discussed four methods of fixating belief: tenacity, authority, agreeableness to reason, and science. Scientific method (or more generally 'disciplined inquiry') means that any rational agent can repeat the same method and should come to the same conclusion.

<sup>9</sup> Other 'mental structures' can result from 'learning', such as beliefs that are unwarranted by the method of science, such as authority or agreeableness to reason. 'learning' can also create 'mental structures' for wrong opinion, and for ineffective and unethical conduct.

<sup>10</sup>  $Q$  is the unique object of 'knowing'.

- *'Knowing that'*: 'mental structures' for beliefs warranted by 'disciplined inquiry'
  - *'Instantial'*: classification of objects of the same kind.
  - *'Relational'*: rational explanation of relationships between kinds of objects.
  - *'Criterial'*: rational judgment of kinds of objects and their relations according to a norm.
- *'Knowledge'* =<sub>Df</sub> 'record of knowing' =<sub>Df</sub> preservation of 'signs' that represent what is known in some medium external to knower
- *'Disciplined inquiry'* =<sub>Df</sub> 'rigorous research' =<sub>Df</sub> 'learning' which is regulated by criteria for creating 'scientific', 'praxiological', and 'philosophical' 'knowledge'.<sup>11</sup> (See Figure 1.9.)
- *'Instrumentally good'* =<sub>Df</sub> means that are good for an end (goal)
  - *'Means'* =<sub>Df</sub> course of action, a way to reach an end (goal)
- *'Intrinsically good'* =<sub>Df</sub> means or ends that are good in themselves, not with respect to their instrumental goodness
- *'Effective Education'* =<sub>Df</sub> 'education' that is 'instrumentally good' (Steiner, 1988, pp. 16-17) (See Figure 1.5.)

<sup>11</sup> Of course, persons who are called 'teachers' can work together with students in 'disciplined inquiry'. In this case they are both intending to 'learn' something that is unknown to either. In this sense, the 'teacher' is not acting as a guide because he or she does not know their destination. Rather they are exploring together—attempting and intending to 'learn' something new. The process of 'disciplined inquiry' is regulated by criteria. This is different from when a 'teacher' is leading a 'student' to a known outcome, such as repeating an experiment that has already been done—e.g., by dropping a feather and a golf ball in a vacuum, to "discover" that their acceleration is the same. The 'student' might 'learn' something new in this case, but not the 'teacher'. Isaac Newton did not have a 'teacher' to lead him to discover the laws of gravity. Rather, he did this through 'disciplined inquiry'.



- *'Effective Bad Education'* =<sub>DF</sub> 'education' that is 'instrumentally good' but not 'intrinsically good' (See Figure 1.12.)
- *'Worthwhile Education'* =<sub>DF</sub> 'education' that is both 'instrumentally' and 'intrinsically good' (Steiner, 1988, p. 17) (See Figure 1.7.)
- *'Totally Integrated Education'* =<sub>DF</sub> 'education' that results in 'student' '**completely-connected**' 'knowing', intention and feeling. See Frick (2017).

## 12. Appendix B: Examples of kinds of knowing

### *'Knowing that one'*

Let us use the symbol  $Q$  to represent an object, and a subscript to index each unique object. For example, in Figure 3, let us use  $Q_1$  as a further 'sign' for representing the 'screen-porch-built-by-Ted-in-1993';  $Q_2$  represents the unique person Theodora; and  $Q_3$  represents the unique person Miguel.<sup>12</sup> How can we tell if someone can *recognize*  $Q_1$ , that is, *knows-that-one- $Q_1$* ? According to Maccia (1978), the cognition is of "none other." To recognize  $Q_1$ , requires that it be discerned from all else. To select  $Q_1$  from not-  $Q_1$ , and to select not-  $Q_1$  from  $Q_1$ , is to *recognize*  $Q_1$ .

### *'Recognitive knowing that one'*

Recognition is a fundamental cognitive act. It is required for identification of each unique object. It is the cognitive act that is required of a witness in a court of law who is asked to identify the defendant as the one the witness observed to commit the crime. The witness on the stand is asked by the lawyer to select  $Q_i$  from all else, where  $Q_i$  is that-one unique individual. When the selection is correct or accurate, we say that a person has *right opinion*.

Plato made this distinction between right opinion and true opinion in *Theaetetus*. According to Maccia (1978):

<sup>12</sup> I am not using the full names of these unique individuals who are real individuals I know, nor am I providing further indices to identify them to protect their privacy. Further details on the screen porch are provided in the section on 'signs' and 'knowledge'.

Right opinion was described [by Plato] as the direct apprehension of things. True opinion was described as conception which was justified by definition or classification. In leading Theaetetus to see that right opinion was not equivalent to true opinion, Socrates had him conclude that it was impossible to distinguish Socrates or Theodorus from any other snub-nosed person by means of definition or classification. He brought Theaetetus to agree that he and Theaetetus would recognize each other when they met next at the Agora. (p. 213)

*True* opinion is 'knowing that' whereas *right* opinion is 'knowing that one'. True opinion requires description whereas recognition does not. Maccia (1986) explains further:

Shared attributes enable comparisons of class membership of things, thereby enabling definitions. Through definitions we come to "know that" to have true beliefs about the relations of things. We have an explanation.

Characteristic attributes, on the other hand, are incomparable. Such attributes locate the betweenness of things. We come to know "that-one," not an instance of a kind. One can argue about the adequacy of a definition, but one can only acknowledge a unique. If you know it, you have the right opinion of its identity as an existent. (pp. 5-6)

Such acknowledgment depends on experience, which is affected by what Peirce (1932) called 'sinsigns.'

A *Sinsign* (where the syllable *sin* is taken as meaning "being only once," as in *single*, *simple*, Latin *semel*, etc.) is an actual existent thing or event which is a sign. It can only be so through its qualities... (2:245)

Sinsigns are the basis of experience. Peirce described experience this way (1931):

We perceive objects brought before us; but that which we especially experience—the kind of thing to which the word "experience" is more particularly applied—is an *event*.... It is the compulsion, the absolute constraint upon us *to think otherwise than we have been thinking* that constitutes experience. (1:336, italics added)

Maccia (1986) further clarified Peirce's category of "Secondness", which distinguishes sinsigns from qualisigns:

Such compulsion is termed by Peirce, "Secondness." Secondness is force by "brute action." The brute action of secondness results in facts. Brute facts that is. Such facts are ... immediate. They are right now. Brute facts mark identity and existence. They characterize the single one. (p. 6)

Dewey (1916) was referring to the same idea as experience and how it can affect our thinking, as discussed in Section 4 above.

Peirce and Maccia's notion of experience is less restrictive than Dewey's, since events can happen that are not our doing—e.g., a strong gust of wind blows sand in our

eyes. Nonetheless, it is the experience, the brute fact, that which compels us “to think otherwise than we have been thinking.”

In another report, Maccia (1987) further explicates 'knowing that one':

*Recognition* will be described as selection through marking the non-comparable features of a thing. Exemplification of recognition will be drawn from studies in perception and pattern recognition. *Acquaintance* will be described as mapping unique relations connecting components of an entity. I shall draw from studies in forensic art and topography. *Appreciation* will be described as a discernment of the fittingness of unique relations connecting constituents of an entity. In exemplifying appreciation, I shall employ modes of judgment for determining authenticity of objects or events. (pp. 213-214, italics added).

#### *'Acquaintive knowing that one'*

Experience, if it is to be grounded, requires immediate perception of the object. Returning to Figure 3, if you the reader have never been physically inside or near Ted's screened porch, then your experience lacks grounding<sup>13</sup>. You may observe the symbolic 'signs' of the unique persons represented in Figure 3 (i.e., their names: Theodora and Miguel), but you would not 'know that one'  $Q_2$  or  $Q_3$ . Unless you had met them before, you would pass right by Theodora or Miguel on the street without recognizing either of them. Moreover, you would not be *acquainted* with them. You would not know that Miguel is a

<sup>13</sup> Sadly, this unique screened porch was destroyed by a large tree limb that was felled by a tornado in May, 2011. Thus, this particular screened porch no longer exists, only records of it such as photographs. See <https://www.indiana.edu/~tedfrick/screenporch/>. You, the reader, may appreciate that-one screened porch via 'indexical signs' of it such as these photographs, but your experience of it would be mediated by those 'signs' and would not be an authentic experience unless you had visited it before the screened porch was destroyed.

software engineer and appreciates listening to live performances of the Chicago Symphony Orchestra. You would not know that Theodora enjoys Cypriot and modern dancing, and is a talented graphic artist.

'Acquaintive knowing that one' requires more than recognition. Acquaintance requires identification of relationships that determine the uniqueness of  $Q_i$ —relationships that set  $Q_i$  apart from all else, what makes it unique. For example, if you were acquainted with the unique screened porch represented in Figure 3 and also depicted in photographs at <https://www.indiana.edu/~tedfrick/screenporch/>, you might notice the particular picture window pattern of sections, and that it was built inside and under an existing awning with steel supports embellished with a leaf pattern. You might notice that wind chime hangs in the center section on the west side, but you would not know that it was a gift from friends who brought it back from a trip to South America, and consisted of slices of a particular rock crystal from Uruguay. Nor would you know the way that particular wind chime sounded, as it twisted in the breeze. You might not have noticed in one of the photos the tall tulip tree behind the vegetable garden to the west silhouetted in the sunset. Nonetheless, this writer has been well-acquainted with that-one screened porch, and its immediate surroundings. Were you to visit this location after July, 2011, you might notice that the screened porch which is now there is *not* that-one-screened-porch-built-by-Ted-in-1993. If you knew the unique original screened porch, you would recognize that the one now there is not that-one-originally-built-by-Ted that is shown in the photographs at <https://www.indiana.edu/~tedfrick/screenporch/>.

*'Appreciative knowing that one'*

Appreciation requires more than recognition and acquaintance. Appreciation requires qualitative judgment as did a colleague when initially sitting inside the screened porch. He had a spontaneous “aha moment” when looking out: “Now I get it! You designed it [the screen porch] this way so we can see the backyard and garden better.” His acknowledgment indicated his *appreciation* of the ‘picture window’ design element of this particular screened porch. See Figure 2.

‘Appreciative knowing that one’ means ‘mental structures’ to identify relationships which are *appropriate* of  $Q_i$ —a valuation of what is special and fitting about  $Q_i$ . When a connoisseur identifies the special qualities of a particular wine after smelling its bouquet and tasting it, this is a further example. She might indicate this by saying, “Ah, this is a superb wine!” This would be a ‘sign’ of appreciation of that-one-wine.

Another example of appreciation occurred during a usability test of a particular software product by a person who said, “This is *awful!* Do you expect students to use this?” Appreciation does not have to be positive. Clearly, from the frustrating experience of trying to use that product, this parent of a college ‘student’ was literally disgusted with the poor quality of the product her son would have to use in school.

In summary, *'knowing that one' requires right opinion of the unique object*. To have right opinion requires at minimum recognition of that unique object. Recognition, in turn, is necessary for acquaintance; and acquaintance is necessary for appreciation. When the experience of the object is immediate, then such knowing is literally grounded. The

relation between the 'sign' and the object represented by the 'sign' is clearly evident to the person who knows-that-one.

### ***'Knowing how'***

In considering *'knowing how'*, it is important to note here that *no* distinction is being made between mind and body. 'Knowing how' is a kind of cognition, as is 'knowing that one' and 'knowing that'. 'Knowing how' consists of 'mental structures' for effective conduct.

As with the other kinds of cognition, we cannot observe a 'mental structure' for 'knowing how' directly, but we must infer it by observing the person carry out successfully some task which requires the 'knowing how' to do so. Thus, we must look for *indicators* or 'signs' of such 'knowing how'.

For example, we cannot tell if Miguel has the capability to write software in Java by somehow peering into his mind. We could ask him if he has this capability, and his response would be an indicator. We could design a task for him to do in Java, and then observe how well he does it. Or we might use other indicators, such as examining Java source code he wrote on the job as a software engineer.

### ***'Protocolic knowing how'***

For *'protocolic knowing how'*, a person follows one path to reach the goal, by duplicating or reproducing the way in which someone else has done it. 'Protocolic knowing how' is inflexible. A person's capability to follow a recipe in cook book to prepare food is an example of *'protocolic knowing how'*. Another example would be to carry out data



analysis by mimicking the step-by-step procedure listed in a statistics textbook, such as performing an ANOVA (analysis of variance).

Estep (2006) refers to this kind of 'knowing how' as *rule-governed* (see p. 226 and 263) in which single-pathed doings are contrasted with *rule-bound* ones which are multi-pathed. Maccia (1988) referred to the former as '*protocolic knowing how*' and the latter as *conventional*.

#### *'Adaptive knowing how'*

In '*adaptive knowing how*', a person can achieve a goal through alternative existing paths, not just one path as in '*protocolic knowing how*'. Because there are multiple paths, and more than one way to accomplish the goal, this is flexible '*knowing how*'. Moreover, one chooses paths based on the specific conditions encountered when the person does evidence it through performance. Thus, such '*knowing how*' is adaptive. Estep (2006) referred to this kind of knowing as *rule-bound*, and Maccia (1988) called it *conventional* '*knowing how*'.

From an educational perspective, an important criterion for assessing achievement of '*adaptive knowing how*' is sometimes described as '*transfer*' of learning. That is, if one has achieved '*adaptive knowing how*', then she or he can transfer the '*knowing how*' to new situations and perform successfully. When this kind of '*knowing how*' is done at a very high level of complexity, it is exemplified by what surgeons, airline pilots and chess players do as experts. They are able to adapt their doing, according to the specifics of a given situation. They are very good at reaching their goal across a wide range of conditions because they are flexible. Their '*knowing how*' is highly adaptive. It is clearly more than

imitation of someone else's doing. They may take a specific combination of pathways that no one else has ever done before. Such capability is not merely a reproduction of a fixed way of doing something, although at least one pathway will be a strict imitation. Protocolic knowing is necessary for adaptive knowing. But 'adaptive knowing now' is more in that it is evidenced by multiple paths to a goal, and different paths are chosen based on specific conditions.

*'Creative knowing how'*

'Creative knowing how' is evidenced by innovating or inventing a new way of doing—a new way to reach the same goal, or even a new goal itself—breaking new ground, so to speak. In medical surgery, for example, a new way of repairing injuries to knee joints via use of an arthroscopic device was developed. At one point, such a surgical method did not exist. Instead of making a large incision to get to the location of the injury, a small incision is made into which such a device is threaded. In contrast to open surgery, it is a remote method of performing the operation, which does less damage to surrounding tissue, results in faster patient recoveries, etc. This is evidence of 'creative knowing how'—arthroscopic knee surgery.

As different example, the Wright brothers invented a new way for manned flight. Instead of trying to make a machine that flapped its wings in imitation of how birds fly, they employed the idea of propelling a plane through the air that had stationary airfoils as wings.

Clearly, 'creative knowing how' is not protocolic and it is more than adapting existing ways of doing. While the examples above are well recognized because of

subsequent widespread adoption, such adoption or success is not a requirement for 'creative knowing how', rather it can be a by-product. The products of 'creative knowing how' have often been important for the advancement of civilization and culture.

'Creative knowing how' is also evidenced by devising a new end or goal. It is not reproducing something that already exists, but what results is something new that did not exist before. When Einstein developed the special theory of relativity, this was a new theory. When Frank Lloyd Wright designed the Fallingwater house<sup>14</sup> in Mill Run, Pennsylvania, this was a new architectural design. When the Diffusion Simulation Game was originally designed as a multi-player board game, it was a new way of 'learning' about Rogers' theory of diffusion of innovations (Molenda & Rice, 1979). The invention of the first spreadsheet program, VisiCalc, by Dan Bricklin and Bob Frankston is a further example of 'creative knowing how'. The theory of relativity, Fallingwater house, the Diffusion Simulation Game, and VisiCalc were new when they were created—they did not exist before.

'Creative knowing how' is not restricted to invention of new methods or things—it can also result in new theories and new 'knowledge'. Nor is 'creative knowing how' restricted to the fine arts—such as making a new sculpture or new music composition. Practical arts can be creative, such as design of new structures in architecture, or new machines such as the iPad or the Airbus A380.

Once a new way of doing has been created, then afterwards when others follow the new way, or they reproduce the same goal, for these others it would be 'protocolic knowing

<sup>14</sup> <http://en.wikipedia.org/wiki/File:FallingwaterWright.jpg> .

how'. They could be taught the new method. For example, many surgeons learned the new arthroscopic method after it was initially invented and demonstrated to be practical and safe. It then became one more technique in their surgical repertoire. As another example, the invention of symbol systems (that we call language) is also evidence of 'creative knowing how'. At one time writing itself was a new way to signify experience. Once this new method of communicating was invented, others could then be taught to write using those symbols.

One might wonder what 'mental structures' for 'creative knowing how' might be or whether such structures are possible. TIE theory (Frick, 2017) posits that this is a kind of 'knowing how' that requires both 'protocolic' and 'adaptive knowing how', and yet 'creative knowing how' is something more. A new means or a new end is created. To list a few well-known cases: Thomas Edison invented the light bulb, Charles Goodyear the vulcanization of rubber, the Wright brothers the airplane, Henry Ford the assembly line for mass production, Charles Babbage the first programmable computer, etc. The evidence that humans have this capability is a matter of historical record, and some of these creations or inventions have had major impacts on civilization and culture.

However, the result of 'creative knowing how' does not have to be well known nor necessarily unique. For example, when I designed and built the screen porch that was discussed above, it did not exist before. I did not follow a blueprint that someone else had created, which would have been 'protocolic knowing how'. For me, the design was original. Somewhere there may be some other screened porch like this one that someone else has designed, and for him or her it could have been likewise 'creative knowing how'.

### **'Knowing that'**

'Knowing that' involves cognition of similarity or commonality among objects or things. Such discrimination of commonality (i.e., similar vs. not-similar) was important from an evolutionary perspective. Survival often depended on making such discriminations—e.g., those who learned to comprehend the pattern of 'hurt or die from falling from a high place' survived longer than those who ignorantly stepped off cliffs or jumped from trees. Early humans may not have had the same concepts of 'mass', 'velocity' and 'acceleration' that Newton later formalized into his laws of gravity, but survival favored those who could predict the consequences of falling from high places, and who avoided such falling. Survival also favored those who could further discriminate kinds of plants or fruits that were poisonous and avoided eating them. These are generalizations, or 'knowing that' as a *'kind of'*—i.e., it is classificatory.

The relatively modern game of *Charades* exemplifies the challenge of signing 'knowing that' *without* symbols—without being able to use words—before symbolic human languages were invented. 'Knowing that one' and 'knowing how' can be achieved without use of symbols. Indeed, other living beings can come to 'knowing that one' and 'knowing how' without using symbols. A dog or cat can recognize its owner and the place where they live ('knowing that one'). These animals exhibit 'knowing how', such as being able to find their way home. When a dog barks at the approach of an unrecognized stranger, that is an 'indexical sign'. Some dogs and cats can signal intent to leave a residence by pawing at a door to the outside.

*'Instantial knowing that'*

When we have an idea (concept) that is associated with more than one unique object of the same kind, then we are instantiating. For example, consider the notion of 'female'<sup>15</sup>. This idea can be used to classify individuals who fit the *kind* that is being signified.

'Instantial knowing that' requires discrimination and classification, which is a sorting of things into one kind or another according to common properties or characteristics. We make the classifications that Theodora is a female, while Miguel is not. We logically distinguish that-kind and not-that-kind when we classify instances.

On the other hand, if one can recognize Theodora, clearly being able to separate her from all else (as none-other, who is unique), this is 'knowing that one'. Yet at the same time we can state a fact about her, which is 'instantial knowing that': Theodora is 'female.' When we state such a fact and it is warranted, then this is a 'sign' of 'knowing that' about the instance, Theodora.

Peirce (1932) referred to 'symbolic signs' that are used to represent classifications (in contrast to indexes and icons). 'Symbolic signs' are legisigns (e.g., 'female', 'screened porch'), which are used to represent *classes* of objects. Legisigns may differ according to language, such as Spanish, Greek or Macedonian. Nonetheless, the same concept can be symbolized as a class for which objects of the same kind can be classified, and the cultural legisign is used to represent the class.

<sup>15</sup> While this concept can be represented symbolically, as in the English word 'female', it could be represented iconically as it often is on entrances to women's restrooms in international airports.

When we classify objects as instances, we no longer are treating each as unique. We often use the article, 'a', not the article 'the' in English, when we achieve 'knowing that'. When we refer to *the* screened-porch-built-by-Ted represented by the photo in Figure 3, we use the article, 'the', to indicate the unique or particular, just as we would indicate *the* person whose name is Theodora. Whereas, when we refer to *a* screened porch, then we are treating the object as an instance of a class of objects of the same kind.

*'Relational knowing that'*

For '*relational knowing that*', more than '*instantial knowing that*' is required. One must know a *kind of relationship* between two or more classes of objects. Consider the screened porch example once again in Figure 3. Theory about visible light was relevant to the window design within each panel. Some kinds of objects will allow visible light to pass through and others will not. Light will be blocked from passing through solid wood, but it does pass through fine, aluminum screen mesh. The fine screen mesh will allow light, wind, rain and snow to mostly pass through this filter, whereas it will prevent mosquitoes and other larger things from entering. These theoretical relationships were considered in the structural design of the window<sup>16</sup>. Several concepts have been mentioned, including: visible light, window, aluminum screen, solid, wood, filter, mosquitoes, passing through, wind, rain and snow. Each of these is a class which can be instantiated by many objects that can be sorted into these classes.

<sup>16</sup> Note that this example also illustrates the connection of 'knowing how' and 'knowing that'.

But there are *relationships* between these kinds of objects. For example, 'wind (moving air)' 'passes through' 'aluminum screen'. Here the kind of relationship is 'passes through' and one kind of object is 'wind' and the other kind is 'aluminum screen'.

Furthermore, there can be classes of classes. 'Aluminum screen' is one kind of 'filter'. 'Plexiglas' is another type of 'filter'. 'Filter' is the superclass. In fact, 'superordinate' is itself a type of relationship.

Generalizable relationships constitute the content of science, praxiology and philosophy (Steiner, 1988). Scientific 'signs' of 'knowing that' are important for explaining and predicting phenomena, such as Einstein's famous equation that symbolizes the relationship between matter, energy and light ( $E = mc^2$ ). Praxiological 'signs' of 'knowing that' symbolizes relationships between means and ends, which are 'instrumentally good', such as the process of tempering steel in order to strengthen it. Philosophical 'signs' of 'knowing that' symbolizes general relationships which are 'intrinsically good', such as the ethical principle that human beings ought to treat each other with benevolence and justice.

*'Criterial knowing that'*

'Criterial knowing that' requires 'instantial' and 'relational knowing that' but involves a norm beyond them so that judgment (evaluation) of such concepts and relations is possible. 'Meta-theoretical' is another term that could be used for 'criterial knowing that', where 'meta-' means 'beyond' or 'transcends'. The judgment requires a standard that transcends the theory itself and its terms.

For example, 'logical truth' is a standard or criterion. Suppose there are two assertions: "Theodora is a female." and "Theodora is a male." If the categories of gender



(male, female) are mutually exclusive, then both of the assertions cannot be rationally held at the same time without violating the notion of logical truth ( $P$  and  $not-P$  is logically false—i.e., either  $P$  is true or  $not-P$  is true, but not both).

Consider the proposition from the screened-porch example: “Wind passes through aluminum screen mesh.” This is a different kind of proposition in that it is not a fact about an individual object but instead about all objects in the classes involved—anywhere, anytime, anyplace. Even if it is the case that wind passes through the screen on the porch that Ted built, this does not mean that this relationship will hold for all instances of wind and all instances of aluminum screen mesh.

What kinds of evidence would be needed to warrant the assertion about the general relationship between wind and aluminum screen? What criteria are needed to make such a judgment? For example, if the criterion is ‘empirically holds without exception’ and just *one* counter-example is discovered to exist, then the assertion is *not* warranted according to that criterion. In various scholarly disciplines (e.g., chemistry, physics, biology, anthropology, philosophy, etc.), there is considerable discussion about research methods and criteria that are appropriate for warranting claims. Such a discussion about research methodologies in ‘disciplined inquiry’ is beyond the scope of this report.

### **13. Appendix C: Lose weight? Or decrease ‘fat’ mass?**

The following example from biochemistry illustrates the importance of precise terminology to describe what we are talking about, and how the chemical factories in our body operate so we have energy to stay alive and to move around. As it is, this is a

somewhat oversimplified explanation, but is nonetheless consistent with biochemistry in our bodies and how our 'hormones' and 'enzymes' regulate 'metabolism' (McKinley, O'Loughlin, & Bidle, 2016).

According to estimates by the National Center for Health Statistics (2015), about 1 out of every 3 Americans 20 years or older is obese, and 2 out of 3 are overweight (Taubes, 2016). This problem is significant because people who are obese are more likely to develop Type 2 diabetes, and subsequently are predicted to be more likely to die from heart disease, stroke and cancer. What can we do about this situation?

First, the problem is *not* that most Americans are overweight. We could ship them all to the moon, and they would 'weigh' about one-sixth of what they now do on earth. That would work immediately, but would not address the underlying problem.

More to the point is that too many individuals have an excessive 'mass' of 'fat' stored in their bodies. The problem is not solved by losing 'weight', rather the problem is solved by reducing excess 'mass' of 'fat' stored in our bodies. I am using single quotation marks to identify well-defined terms.

So what is human 'fat'? Technically, body 'fat' is stored in 'adipose cells' largely as 'triglyceride' 'molecules'. When we consume 'carbohydrates', they are broken down into 'glucose' 'molecules' (and others). Our 'pancreas' secretes the 'insulin' 'hormone' in order to lower our blood sugar level (amount of 'glucose'). Some of the 'glucose' is immediately taken in by 'cells' in our bodies for energy via a 'metabolic' process called 'glycolysis', but a further process called 'lipogenesis' converts extra 'glucose' into 'fatty acids', and, in the presence of 'insulin' and 'lipoprotein lipase', those 'fatty acid' 'molecules' are combined

with 'glycerol' 'molecules' in a three-to-one ratio to form 'triglyceride' 'molecules' stored as body 'fat' (in 'adipose tissue cells').

Notice we are now using specific, well-defined terminology in physiology, anatomy, biochemistry and physics to describe the problem. In order to address obesity, we need to reduce the 'mass' of 'fat' stored in 'adipose tissue'. And to be even more specific, we normally do not want to reduce the mass of our 'skeletal muscle tissue', 'tendons', 'ligaments', 'organs', and 'bones'. We do not want to end up as 98-pound weaklings. And we do not want to get rid of all fat stored in 'adipose tissue' because 'fatty acids' are needed as fuel for creating 'energy' when insufficient 'glucose' is currently available.

So how does our body extract the 'fat' from 'adipose tissue'? This is more complicated, because our bodies have multiple metabolic pathways (different ways our 'cells' create needed energy, depending on conditions). Our bodies first use available 'glucose' in our bloodstream for 'cells' to 'metabolize' for energy through a process called 'glycolysis'. If our 'glucose' level is too low (also low 'insulin' level), then our 'pancreas' secretes 'glucagon', a 'hormone' which in combination with the 'enzyme' 'hormone sensitive lipase' signals 'adipose cells' through a process called 'lipolysis' to break down 'triglycerides' into 'free fatty acid' and 'glycerol' 'molecules' that are released into the bloodstream. The 'free fatty acids' are then metabolized by our cells to create energy. So the problem is not to consume fewer calories than we expend as energy, as is often misunderstood. The problem is to release more fat than we store. Therefore, solutions should address metabolic pathways that lead to fat storage and to fat release for use as energy.

One effective method is to stop eating. The starvation method works—note the appearance of people who are starving to death, literally ending up looking like “skin and bones” (little ‘muscle’ and ‘adipose tissue’ remains). But starving is unsustainable as a method when we have plenty of food around us.

A further method is to exercise excessively. But that is impractical, with respect to burning any significant amount of fat stored in ‘adipose cells’. There are much more effective methods. Some exercise is good for us, but for other reasons to maintain health.

Unfortunately, the often-recommended method of reducing caloric consumption and increasing exercise does *not*, in fact, work in the long run for 95 percent of us, and is unsustainable (Eades & Eades, 1996; Bailor, 2015). Furthermore, people who try this method often end up with a more fat mass and less lean body mass though ‘homeostasis’. When done repeatedly (a “yo-yo” dieting pattern), this in effect exacerbates the fat mass problem (e.g., see Taubes, 2011; Bailor, 2015).

What is needed is a solution that stimulates our bodies to extract ‘fatty acids’ from ‘adipose cells’ and burn them for needed energy. And to do this at a rate that is greater than the rate of storing ‘fat’ in ‘adipose tissue’. Over time, this will reduce the mass of ‘fat’. Understanding of ‘metabolic processes’ in the human body can help us identify strategies that can safely reduce the ‘mass’ of ‘fat’ stored in ‘adipose tissue’ without losing ‘muscle’ mass or eventually starving to death.

Dietary approaches that are effective typically recommend eating proportionally more ‘proteins’ along with a sufficient amount of healthy ‘fats’, and eating proportionally much less ‘carbohydrates’ (that are converted to ‘glucose’ and stimulate ‘insulin’ secretion

by the 'pancreas'). When our 'pancreas' spends more time secreting 'glucagon' than it does 'insulin', our bodies will extract 'fatty acids' stored in 'adipose cells' for energy at a *greater rate* than it stores 'fatty acids' as 'triglycerides'. See Eades and Eades (1996, pp. 34-37). It is a problem of the *rate* of 'feedin' of 'fatty acids' and 'glycerol' to 'adipose tissue cells' when contrasted with the rate of 'feedout'. 'Feedin' and 'feedout' are 'system' properties (e.g., see Thompson, 2008a; Maccia & Maccia, 1966). The daily *quantity* of total calories we consume is less significant than *quality* of macro-nutrients we proportionally consume, the *rate* of consumption of those macronutrients during the day, and the energy demands of muscles cells (to move our bodies) throughout the day.

It is a *rate* problem, not a *weight* problem, and it is specifically about rates of different metabolic pathways our bodies use to create energy to stay alive and to move about.

While this 'fat' metabolism example is oversimplified (there are additional metabolic pathways not discussed here such as 'ketosis' and 'gluconeogenesis'), it nonetheless illustrates the value of well-defined terminology, so we all know precisely what we are talking about. It further clarifies how we frame a problem and potential solutions to the problem.