The Theory of Totally Integrated Education: TIE

A Monograph in Five Parts

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Abstract

The Theory of Totally Integrated Education (TIE) predicts that mental structures formed by learners are expected to be stronger when ‘knowing that one’, ‘knowing how’, and ‘knowing that’ are integrated with learner emotions and intentions. Such whole, completely connected mental structures are expected to be less vulnerable to forgetting. TIE theory further provides justification of principles for worthwhile education. TIE theory builds on seminal work of John Dewey, Charles Sanders Peirce, Maria Montessori, Elizabeth Steiner, George Maccia, Stanley Greenspan, Kenneth Thompson, Myrna Estep, Eric Kandel, David Merrill, and Jeroen van Merriënboer. Descriptive theory is provided which defines terms in TIE theory, before it is explicated and examples are provided. A strategy for improving curriculum is recommended, which is based on sequencing authentic, whole learning tasks from simple to complex. Most importantly, these learning tasks are expected to help students integrate 9 kinds knowing with emotions and intentions: recognitive, acquaintive, appreciative, protocolic, adaptive, creative, instancial, relational and criterial.

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Section 1: An Overview of TIE Theory

Introduction

Why is it that the majority of U.S. high school students are bored every day in school? Yazzie-Mintz (2007) summarizes results from a survey of 81,499 students in 110 high schools across 26 U.S. states. Approximately 2 out of 3 students said that they were bored in class every day. When asked why they were bored, the top reasons were that learning materials were uninteresting, irrelevant and not challenging enough. Yazzie-Mintz cited one student who stated, “Our school needs to be more challenging. Students fall asleep because the classes aren’t really that interesting.” Another said, “School is easy. But too boring. Harder work or more is not the answer though. More interesting work would be nice” (p. 10).

Students who considered dropping out of school indicated that the main reasons are dislike of their school and teachers. Sixty percent further said, “I didn’t see the value in the work I am asked to do” (p. 5). For those who stay in school, the primary reason they do so is to get their high school diploma, so that they can go on to college.

Likewise, many of us have experienced taking classes in our formal education, or even on the job, during which we were constantly asking ourselves, “Why am I taking this class? Why do I need to learn this stuff? Who cares about this subject? This is so boring. I wish I were doing something else.”

Every once and a while, we may have been fortunate take that rare class or course that was terrific. Our teacher was great. We were totally immersed. We could not learn enough. We spent hours absorbed completely, unaware of the passage of time. Something inside us just resonated. We felt happy. We would spend countless more hours outside of class, continuing to learn on our own time. This learning was very important to us.

So, what was the difference between the former and latter experiences, from the point of view of the student—an utter waste of time versus experiencing elation, flow, and wanting to learn more? The theory of Totally Integrated Education aims to explain why. More importantly, TIE theory should help parents, teachers, curriculum developers and instructional designers to create student learning experiences which more often result in the latter situation.

Students will be thankful. Especially those who have to go to a place called school or college. Also students who are learning on the job outside of the formal educational setting called school will be thankful.

Introduction to TIE Theory

Education is not just learning. Figure 1 illustrates the relationship between learning and education. Learning can occur without guidance—i.e., without teaching. To be education, however, learning must be both guided and intended (Steiner, 1988). Furthermore, not all education is effective or worthwhile.
The theory of totally integrated education (TIE) describes what is necessary for worthwhile education. TIE theory further predicts that mental structures will be strongest when student willing, feeling and thinking are working in concert as she or he engages in learning tasks:

- $S$ intends to learn $X$.
- $S$ feels good about learning $X$.
- $S$ forms mental structures for $X$ (i.e., $S$ learns $X$).

where $X$ is the integration of ‘knowing that’, ‘knowing how’ and ‘knowing that one’, and $S$ is the student.

According to Greenspan and Benderly (1997), the emotion arising through engagement in a learning task creates the architecture of the student’s mental structure. This structure increases in complexity—there are more connections in a person’s mental structure than before, which is the definition of learning in TIE theory. The dual coding of sensations and emotions from that experience organize the mental structure.

Figure 2 illustrates graphically the desired relationship among thinking, willing and feeling during the learning process. Cognition, intention and emotions are in harmony (in sync), rather than being at odds with each other. Ideally the learning task is something that the student has chosen to do, his or
her thoughts are focused on the learning task, and his or her emotions are positive about this activity (it is satisfying).

Figure 2. Schema for desired connections among a student’s cognition (thinking), intention (willing), and emotion (feeling) during a learning activity (graphic by Colin Gray).

Figures 3, 4 and 5 illustrate kinds of knowing. In particular, Figure 5 shows full integration of the 9 kinds of cognitive relations—they are completely connected, which is represented by the arrows between the rounded rectangles. Furthermore, the embedding of the rounded rectangles illustrates the relationship within each kind of knowing. For example, appreciation is a subset of acquaintance and acquaintance is a subset of recognition. Both recognition and acquaintance are necessary (but not sufficient) for appreciation. Thus, if a learning task connects appreciation of that-one, creative ‘know how’ and criterial ‘know that’, then it follows that the 9 kinds of knowing must be connected since the other 6 are necessary for these three.

Figure 3. Illustration of three kinds of knowing (drawings by Elizabeth Boling).
The theory of totally integrated education (TIE) predicts that when three kinds of knowing are integrated (i.e., ‘knowing that one’, ‘knowing how’, and ‘knowing that’ are connected so as to remain whole), and when student cognition, intention and feelings are in harmony, then students will form stronger mental schema—schema that are less vulnerable to forgetting. Consequently, for education to be most effective, teachers should choose multiple learning tasks that require students to make connections among these kinds of knowing for each educational objective.

Furthermore, these learning tasks should be authentic (i.e., selected from the existing culture in which students and teachers live), so that students can see the relevance of the tasks to their personal lives. If students see the relevance and purpose of the tasks, then they are more likely to be motivated to engage in the learning tasks. In the Yazzie-Mintz (2007) study, students who were considering dropping out of school said, “I didn’t see the value of the work I am expected to do” (p. 5). If educators design or choose learning tasks that are authentic, it will help students appreciate the value of those tasks.

Figure 4. Further explication of kinds of knowing (graphic by Colin Gray).
Figure 5. Illustration of completely connected knowing where student cognition, intention and emotions are in harmony—i.e., Figure 2 is superimposed on Figure 4 to result in this figure (graphic by Colin Gray).

Figure 6a. Partially connected mental structures (graphic by Colin Gray). The lack of shading in the rounded rectangles represents absence of connectivity—hence cognition and thinking, willing and feeling are not totally integrated.

Figure 6a illustrates mental structures that are not completely connected. Note the gaps: Criterial relationships are missing with respect to cognition, intention and feeling. Relational (theoretical) connections are missing with respect to intention and feeling. Appreciative relationships are missing with respect to cognition, intention and feeling. Creative relationships are missing with respect to intention and feeling; and adaptive relationships are missing with respect to feeling.

Too often, the picture is even more empty—e.g., attempting to bring students to ‘know that’, without connecting ‘knowing that’ to ‘knowing how’ or ‘knowing that one’. Furthermore, if students do not intend to learn (i.e., are compelled), and their feelings are likewise out of sync, then what is illustrated in Figures 5 and 6a largely disappears. Such a graphic would be mostly empty, with very little to show (Figure 6b). Under these conditions, TIE theory predicts that such disconnected learning—lacking wholeness—will be highly vulnerable to forgetting.
This is the kind of disconnected learning that students often experience in school when they are bored. They are required to learn facts and concepts they do not care about, which have no perceived practical value, and which are disconnected from unique elements in their culture.

![Disconnected mental structures](graphic by Colin Gray)

‘Knowing how’ and ‘knowing that one’ are disconnected from ‘knowing that’. Student intention and emotion are disconnected from ‘knowing that’.

**Definitions of Basic Terms in TIE Theory**

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.

Central to TIE theory are the following defined terms (‘≡_

\text{df} \ ‘ is read as ‘is defined as’) \(^1\):

- **Mental structures** \(=\text{df} \text{ affect-relations}\)\(^2\) which constitute intelligence

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\(^1\) These are other terms are defined at [http://educology.indiana.edu](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.
Learning =_Df_ increasing of complexity of a person’s mental structure

Learner =_Df_ person whose volition is learning

Forgetting =_Df_ decreasing of complexity of a person’s mental structure

We have been discussing ‘mental structure’ above, and now we must be more precise in what we mean. We borrow some definitions here from general system theory, and in particular, Axiomatic Theories of Intentional Systems (Thompson, 2006a; 2006b; 2008a; 2008b). ‘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 person’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 directly relevant to TIE theory. In TIE theory, we assert that humans form mental structures as they learn. To use Steiner’s criterion, there is external coherence. This definition of learning in TIE theory has external coherence with biological knowledge.

Undefined or Primitive Terms

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

More Definitions of Terms in TIE Theory

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 1a through 1m illustrate via shadings in the Venn diagram how these terms are related but yet distinct.

**Accidental learning** =_Df_ learning which is neither guided nor intended (see Figure 1a)

**Discovery learning** =_Df_ learning which is intended but unguided (see Figure 1h)

**Compelled learning** =_Df_ learning which is not intended but guided (see Figure 1j)

**Conducive learning** =_Df_ education =_Df_ learning which is intended and guided (see Figure 1d)

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2 Words which are green colored are defined elsewhere by Thompson (2008). See [http://www.indiana.edu/~aptac/glossary/](http://www.indiana.edu/~aptac/glossary/). These terms, defined in Axiomatic Theories of Intentional Systems (ATIS) can be more conveniently viewed at [http://educology.indiana.edu](http://educology.indiana.edu) by clicking on hyperlinks in the definitions and supplementary explanations and examples.
Figure 1a. Accidental learning: neither intended nor guided

Figure 1b. Guided learning

Figure 1c. Intended learning

Figure 1d. Conducive learning (education): Intended and guided
Figure 1e. Ineffective education: neither instrumentally good nor intrinsically good

Figure 1f. Effective education: instrumentally good

Figure 1g. Worthwhile education: instrumentally and intrinsically good

Figure 1h. Discovery learning: intended but unguided
Figure 1i. Disciplined inquiry (research): discovery learning that is regulated by criteria

Figure 1j. Compelled learning: guided but unintended

Figure 1k. Induced learning: guided but initially-unintended

Figure 1l. Effective bad education: instrumentally good but not intrinsically good
Student =_{DF} a person who intends to learn content with a teacher

Teacher =_{DF} a person who intends to guide another person’s learning

Teaching =_{DF} a teacher guiding another person’s learning (see Figure 1b)

Sign =_{DF} representamen =_{DF} “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 =_{DF} 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 =_{DF} signs of objects and objects selected for student learning

Context =_{DF} system environment of teacher and student that contains content

Education system =_{DF} intentional system consisting of at least one teacher and one student in a context

Knowing =_{DF} mental structures which consist of warranted beliefs\(^3\), right opinions, and capabilities for performance (See Figures 2, 3 and 4)\(^4\)

‘Knowing that one’ mental structures for right opinion
  Recognitive: select the unique Q\(^5\) from not-Q and not-Q from Q.
  Acquaintive: identify relations determinate of the unique Q.
  Appreciative: identify relations appropriate of the unique Q.

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\(^3\) C. S. Peirce (1877) discussed four methods of fixing 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. This is discussed in greater detail in sections 4 and 5.

\(^4\) 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. This is discussed in further detail in sections 4 and 5.

\(^5\) Q is the unique object of knowing.
‘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.

‘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 \(=_{df}\) record of knowing \(=_{df}\) preservation of signs that represent what is known in some medium external to knower

Disciplined inquiry \(=_{df}\) research \(=_{df}\) learning which is regulated by criteria for scientific method, right opinion and effectiveness.\(^6\) (See Figure 1i.)

Instrumentally good \(=_{df}\) means that are good for an end (goal)

Means \(=_{df}\) course of action, a way to reach an end (goal)

Intrinsically good \(=_{df}\) means or ends that are good in themselves, not with respect to their instrumental goodness

Effective Education \(=_{df}\) education that is instrumentally good (Steiner, 1988, pp. 16-17) (See Figure 1e.)

Effective Bad Education \(=_{df}\) education that is instrumentally good but not intrinsically good (See Figure 1l.)

Worthwhile Education \(=_{df}\) education that is both instrumentally and intrinsically good (Steiner, 1988, p. 17) (See Figure 1g.)

Totally Integrated Education \(=_{df}\) education that results in completely-connected knowing, intention and feeling (See Figure 5.)

In the following sections, background of TIE theory is provided, definitions are explained in more detail, and examples illustrate meaning of the terms of TIE theory. Central to this discussion is the distinction between signs, learning, knowing, knowledge, education, and worthwhile education.

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\(^6\) 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.
Section 2: Learning and Intelligence Revisited

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 (cf. van Merriënboer & Kirschner, 2007). 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) (cf., The Republic of Plato). 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 (cf. 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 (cf. 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 (e.g., see Figures 6a and 6b).

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, nearly 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.
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.

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 ‘know how’ that was very important for survival (e.g., for cooking, for warmth). This ‘know how’ was passed from generation to generation through education. This ‘know 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 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 ‘know 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. (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. Older children teach younger children, and adults teach other adults. As the old African proverb states, “It takes a whole village to educate a child.” Clearly, education is a social endeavor, and has been vital to advancement of human civilization and culture.
Section 3: 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, computerized games and simulations, and electronic storage devices to store records such as hard drives, flash memory, and the “cloud” (i.e., 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 (cf. 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 (i.e., 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 stands for (i.e., 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 8, Ted Frick imagined it in his mind, similar to the sketch of one of the panels in Figure 7. 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.

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 8. 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 8. There are three unique objects—two of which are persons and the screened porch—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).

Furthermore, Theodora recognizes Miguel, and Miguel recognizes Theodora, represented in Figure 8 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 8 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.

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7 Obviously, the actual persons, Theodora and Miguel, and the actual screened porch are not in Figure 8, 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).
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 (cf. Peirce, 1977; 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 ‘трем 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 Figures 7 and 8 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, in TIE theory, 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’.

Signs and their objects are relevant to the content of education. Content is defined in TIE theory as signs of objects and objects selected by a teacher for student learning. While a person can come to ‘know that one’ without signs, it is difficult to imagine—through education—a way in which that person could come to ‘know how’ without exposure to indexical signs (such as demonstration of the ‘know how’ by another person such as a teacher). Coming to ‘know that’ would be difficult, if not impossible, without use of legisigns as a teacher guides a student’s learning of concepts, relations and criteria.
Section 4: Types of Knowing

Overview of Types of Knowing

There are three fundamental types of knowing: 1) ‘know that one’, 2) ‘know how’, and 3) ‘know 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 3, 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’ (‘know that’).

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), further characterized as cognitive, conative, and affective mental structures. Since one’s knowing consists of cognitive 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, Polyani (1974) referred to "tacit knowing," which essentially meant private, personal knowings not sharable with others as intersubjective signs.
Without further digression here, 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 ‘know that one’, right opinion is essential. For ‘know how’, conduct must be effective. For ‘know 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. Appreciation requires acquaintance, and acquaintance requires recognition. Creative ‘know how’ requires adaptive ‘know how’ that, in turn, requires protocolic ‘know how’. Criterial knowing requires relational knowing, and relational knowing requires instantial knowing. In other words, within each classification of knowing, the categories are progressively inclusive.

The types of knowing are not mutually exclusive. We can ‘know that one’, ‘know how’ and ‘know that’ with respect to some object. This is illustrated in Figure 3, where the dog Rover, is the object of ‘knowing that one’, ‘knowing how’, and ‘knowing that’.

These kinds of knowing are not necessarily connected, as illustrated in Figure 6. For example, a person’s ‘know that’ could be disconnected with his or her ‘know how’. A person could ‘know that one’ without ‘know how’ or ‘know that’. However, when kinds of knowing are connected as illustrated in Figure 5, then such knowing is completely connected, whole, and expected to be less vulnerable to forgetting.
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 8, 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.\(^8\) How can we tell if someone can recognize \( Q_4 \) that is, knows-that-one-\( Q_4 \)? According to Maccia (1978), the cognition is of “none other.” To recognize \( Q_4 \), requires that it be discerned from all else. To select \( Q_i \) from not- \( Q_o \), and to select not- \( Q_i \) from \( Q_2 \), is to recognize \( Q_i \).

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):

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):

\(^8\) 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.
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 the first part of this paper: intelligence and learning revisited.

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 8, if you the reader have never been physically inside or near Ted’s screened porch, then your experience lacks grounding9. You may observe the symbolic signs of the unique persons represented in Figure 8 (i.e., their names: Theodora and Miguel), but you would not ‘know that one’ Q₁ or Q₂. 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 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 requires more than recognition. Acquaintance requires identification of relationships that determine the uniqueness of Q₁—relationships that set Q₁ apart from all else, what makes it unique. For example, if you were acquainted with the unique screened porch represented in

9 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.
Figure 8 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 8.

To ‘appreciate’ means 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’ is mental structures for effective conduct.

As with the other kinds of cognition, we cannot observe a mental structure for ‘know how’ directly, but we must infer it by observing the person carry out successfully some task which requires the ‘know how’ to do so. Thus, we must look for indicators or signs of such ‘know 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 ‘know how’, a person follows one path to reach the goal, by duplicating or reproducing the way in which someone else has done it. Protocolic ‘know how’ is inflexible. A person’s capability to follow a recipe in a cookbook to prepare food is an example of protocolic ‘know 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 (cf. 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 ‘know how’ and the latter as conventional.

**Adaptive ‘knowing how’**

In adaptive ‘know how’, a person can achieve a goal through alternative existing paths, not just one path as in protocolic ‘know how’. Because there are multiple paths, and more than one way to accomplish the goal, this is flexible ‘know 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 ‘know how’.

From an educational perspective, an important criterion for assessing achievement of adaptive ‘know how’ is sometimes described as ‘transfer’ of learning. That is, if one has achieved adaptive ‘knowing how’, then she or he can transfer the ‘know how’ to new situations and perform successfully. When this kind of ‘know 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 ‘know 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 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 protoclic 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\(^1\) 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 ‘know 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 protoclic ‘knowing 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 posits that this is a kind of ‘knowing how’ that requires both protoclic 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 protoclic. For me, the design was original. Somewhere there may be some other screened porch like

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this one that someone else has designed, and for him or her it could have been likewise creative ‘know how’.

**Knowing That**

‘Knowing that’ involves cognition of similarity or commonality among 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 ‘know that one’ and ‘know 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 sign 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’\(^\text{11}\). This idea can be used to classify individuals who fit the *kind* that is being signified.

Instantiation 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.

One 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 instantiation: ‘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 symbols as signs that are used to represent classifications (in contrast to indexes and icons). Symbols 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.

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\(^\text{11}\) 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 ‘know that’. When we refer to the screened-porch-built-by-Ted represented by the photo in Figure 8, 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, more than instantiation 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 8. 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. 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 ‘kind,’ which can be instantiated by many objects that can be sorted into these classes.

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 ‘know that’ is 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 ‘know that’ symbolizes relationships between means and ends, which are instrumentally good, such as the process of tempering steel in order to strengthen it. Philosophical ‘know that’ symbolizes general relationships which are intrinsically good, such as the principle that human beings ought to treat each other with benevolence and justice.

**Criterial ‘knowing that’**

Criterial knowing 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 $\neg P$ is logically false—i.e., either $P$ is true or $\neg P$ is true, but not both).

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Note that this example also illustrates the connection of ‘knowing how’ and ‘knowing that’.
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.
Section 5: Worthwhile Education

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. Signs of how-to-do may not represent worthwhile means to ends. 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).

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. 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 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 “don’t 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

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, we predict 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 ones 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, 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 ‘know how’.

There have been numerous efforts to improve education systems (cf. Moursheid, 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 ‘know how’. Creative ‘know 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 3, one should be able to classify the four-legged animals as ‘dogs’. And the living beings illustrated in Figure 3 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 H₂O, where each molecule consists of two ‘atoms’ of ‘hydrogen’ and one ‘atom’ of ‘oxygen.’

As civilization progresses and knowledge advances (i.e., 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 (cf. 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 (cf. 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 (cf. 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 method of agreeableness to reason.

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 (H₂O). 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 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’ (cf. Maccia, 1987).

Finally, criterial ‘knowing that’ is an important educational objective that should not get lost as we attempt to improve our education systems (cf. Mourseshed, 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.
New Curriculum Needs to Be Designed and Developed for Education

One implication of TIE theory is that extant curriculum for education needs to be reconsidered.

Traditional curriculum in P-16 schools has been carved up to the point that it is often difficult for students to see the relevance and value of learning activities in those subject areas, which is one of the primary reasons students are bored and unmotivated to learn (cf. Yazzie-Mintz, 2007). Metaphorically speaking, Humpty Dumpty has been broken into many small pieces; the whole of Humpty Dumpty has been lost in traditional curriculum subjects such as algebra, geography, science, history, reading, writing, spelling, grammar and arithmetic.

Nearly a century ago Dewey (1916) also observed this problem in education:

... the bonds which connect the subject matter of school study with the habits and ideals of the social group are disguised and covered up. The ties are so loosened that it often appears as if there were none; as if subject matter existed simply as knowledge on its own independent behoof... irrespective of any social values. (p. 181)

The subject matter of the learner is not ... identical with the formulated, the crystallized, and systematized subject matter of the adult.... [which] enters into the activities of the expert and the educator, not that of a beginner, the learner. Failure to bear in mind the difference in subject matter from the respective points of teacher and student is responsible for most of the mistakes made in the use of texts and other expressions of preexistent knowledge. (pp. 182-183)

In TIE theory, the goal is to help learners create mental structures that are whole by attempting to completely connect the kinds of knowing with intention and emotion. Learning tasks which are authentic and whole are needed. The criterion of authenticity requires that the tasks should be selected from what people in the social system and culture actually do and which contribute to that social system. Students need to learn to participate in that social system and to be productive members of society, contributing to overall well-being of the social system. As discussed earlier, the primary goal of education is the transmission of culture, and that this has been vital to the advancement of human civilization and culture.

Dewey (1916) recommended the same approach as we now do in TIE theory: engage students in purposeful learning through hands-on experience. Dewey started a laboratory school at the University of Chicago, which still exists, in order to test his ideas. Although his notion of progressive education never caught on in mainstream education, more recent educational approaches such as problem-based learning and project-based learning are consistent with fundamental ideas that Dewey originally promoted.

There are two examples that implement a curriculum consistent with Dewey’s philosophy and TIE theory: Montessori schools and New Tech high schools. While neither of these has become part of mainstream education in the U.S., they nonetheless illustrate that authentic whole tasks can be designed and sequenced which are age- and developmentally-appropriate and which when taken together help students achieve curriculum goals. What is significant in both Montessori and New Tech schools is that the curriculum is arranged around these tasks or projects, rather than subject matter areas in traditional K-12 education.
1) Montessori schools have often been misunderstood by those not trained in the Montessori method because of the complexity of the vast curriculum and the method itself. The curriculum consists of literally thousands of learning tasks called ‘works.’ Much like the tip of an iceberg, only a portion of the curriculum is visible in the classroom at any given time. The genius of Montessori is how she was able to design and validate these ‘works’ that help bring students to achieve goals compatible with those in traditional K-6 education. See Lillard (2008) for an introduction to the scientific basis for the approach and curriculum works that Montessori invented.

Although Montessori and Dewey were contemporaries in the early twentieth century, Dewey was apparently unaware of extent to which his ideas about hands-on, experiential learning had much in common with Montessori’s method and curriculum.

2) Also compatible with Dewey’s philosophy are New Tech high schools, which are a much more recent development, the first one beginning in Napa, California, in 1996. According to the New Tech Network’s website, http://www.newtechnetwork.org:

   The New Tech model provides an instructional approach centered on project-based learning, a culture that empowers students and teachers, and integrated technology in the classroom. Our hands-on, multi-year approach gives schools structure and support to ensure long-term success. (n.p.)

A senior at the Napa New Technology High School is quoted:

   If someone asks, I tell them that my school makes sense. The projects relate to the real world, so I never have to ask “why am I learning this?” It’s challenging but in a good way. The way we integrate technology and presentations gives us skills we will use forever. Our school really prepares us for what comes next. (n.p.)

Similar to Montessori, New Tech high schools have their own unique curriculum consisting of a large number of projects, and New Tech teachers need specific training in the approach and use of the New Tech curriculum. The point here is not to advocate either Montessori or New Tech as the answer to education’s problems, but rather that principles from TIE theory can be used to design and develop curriculum and instruction organized by authentic tasks (rather than “subjects”). Merrill, Barclay and van Schaak (2007) have articulated the difference between task-centered instruction and topic-centered instruction, which illustrates this difference in approach to instructional design. For a specific example, see the report by Mendenhall, et al. (2006). The same goals of topic-centered instruction (subject matter to be learned) can be achieved by task-centered instruction.

A significant challenge is to design and sequence such authentic whole tasks without generating student cognitive overload. Too much cognitive load will interfere with learning (cf. van Merriënboer, Kirschner & Kester, 2003). One instructional design approach shows promise in how to sequence tasks for complex learning while managing student cognitive load: the Four-Component Instructional Design (4C/ID) model (van Merriënboer & Kirschner, 2007). They recommend that instructional designers begin by identifying an authentic, whole, real-world task as the goal. Since such a complex task would be overwhelming for a novice, the essential relationships of the whole task are identified, so that versions of the whole task can be arranged from simple to complex. Each version of the whole task is called a task class. Within each task class, variations of the task are created, along with supportive information, just-in-time procedural information, and part-task practice (if needed). As the learner completes
variations of the whole task in the task class, the amount of support (e.g., teacher feedback, coaching, scaffolding) is gradually faded until the student can perform the entire task independently. Then the student moves to the next task class, which is a little more complex, and the whole cycle is repeated. Students proceed through task classes in this manner until they can successfully perform the original authentic, complex task that was identified as the goal.

What is noteworthy about Dewey’s philosophy, Montessori schools, New Tech high schools and the 4C/ID model is that students are expected to engage in authentic, purposeful tasks or projects. Education can be organized by these tasks/projects, rather than by traditional subjects, and the levels of complexity of these tasks can be matched to what students are capable of doing at their current level of development. The same educational goals can be achieved with respect to traditional curriculum standards, but the means of accomplishing these goals are different.

When instruction and learning activities are grounded in authentic tasks, a further benefit is that students will come to ‘know that one’ in the process of learning. As Estep (2006) observed, tasks for ‘knowing how’ are grounded in particulars—i.e., such authentic tasks are performed in a unique context. Furthermore, many kinds of ‘knowing how’ benefit from ‘knowing that’. In other words, students can apply generalizable concepts, relations and criteria as they carry out a specific task. Performance of these tasks can help students connect their mental structures for ‘know how’ with ‘know that one’ and ‘know that’.

**Principles for Determining Worthwhile Education**

It should be the responsibility of one generation to transmit the best of culture to the next generation. What culture is worth passing along? What should the goals of education be?

In TIE theory, we have provided principles for worthwhile education. To summarize, with respect to:

- **‘Knowing that one’**, students should experience authentic elements of existing culture. They should have right opinion through recognition, acquaintance and appreciation of unique parts of their own culture.

- **‘Knowing how’**, 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—whether their doings are protocolic, adaptive or creative.

- **‘Knowing that’**, students should come to hold warranted beliefs. Students should come to know generalizations which are intersubjectively warranted through disciplined inquiry, and to be able to justify rationally those generalizations—whether for concepts, relationships or for criteria.

When the nine kinds of knowing are completely connected, then we have totally integrated education. See Figure 9.
Figure 9. Totally integrated education: nine kinds of knowing are completely connected.

Figure 10. Worthwhile education (represented by the small circle in the center).
The content of education should exclude the teaching of wrong opinions, ineffective and unethical conduct, and unwarranted beliefs. These goals are not worthwhile.

The best of culture demands right opinion (‘knowing that one’), effective and ethical conduct (‘knowing how’), and beliefs that are warranted (‘knowing that’). These goals constitute worthwhile education. Worthwhile education is defined as intended, guided learning which is both instrumentally and intrinsically good. See the small circle in the center of Figure 10. This is what we should aim for in education. TIE theory predicts that learning will be whole and least vulnerable to forgetting when the nine kinds of knowing are completely connected.

In summary, we should seek worthwhile education. Students should learn the best of culture. The theory of totally integrated education (TIE) provides principles for achieving worthwhile education.

References


