From Systems Theory to Practice: Totally Integrated Education (TIE)

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Abstract

We use systems theory to explain why totally integrated education (TIE) is expected to result in more robust student mental structures. In other words, learning activities which incorporate TIE system principles should be more effective with respect to long-term student learning achievement. Two systems theory models helped generate TIE principles. Through implementation of TIE principles during instruction, student learning experiences are expected to result in formation of stronger mental structures that are less vulnerable to disconnectivity. System structural properties of *strongness*, *wholeness*, and *integration* are key ideas. TIE is consistent with emerging empirical findings in neuroscience, as reported in *Scientific American* in July 2019, on how each of our unique minds emerges from our brain's complex networks. In addition to providing a brief overview of TIE, we describe existing education systems in which TIE principles are exemplified which include Unionville Elementary School; Bloomington Montessori School; and several programs at the State University of New York in Cobleskill.

Introduction

Kurt Lewin was known for saying, "Nothing is as practical as a good theory" (Greenwood and Levin, 1998, p. 19). That is certainly true for totally integrated education (TIE), which was influenced by systems theory and thinking—especially SIGGS (Maccia and Maccia, 1966) and ATIS (Thompson, 2006). Before discussing TIE, some background on SIGGS and ATIS is necessary.

The SIGGS theory model was originally used to develop a theory of education, consisting of 201 hypotheses. See https://tedfrick.sitehost.iu.edu/edutheo.html. SIGGS is grounded in set (S), information (I), di-graph (G) and general systems (GS) theories. SIGGS is a complex theory model with precise definitions of system dynamic and structural properties such as toput, strongness, adaptability, stress, wholeness, and integration.

SIGGS was an important theory model that initially influenced the conception of *totally integrated education* (TIE). The SIGGS notion of affect relations (connections among system components) and properties of affect-relation sets in systems was central. The structural properties *strongness*, *wholeness*, and *integration* were key ideas. In the SIGGS theory model (Maccia & Maccia, 1966), 22 structural properties were defined, for example:

> "Complexness is the number of connections" (p. 62).
> "Flexibleness is different subgroups of components through which there is a channel between two components with respect to affect relations" (p. 59).

> "Strongness is not complete connectedness and *every two components are channeled to each other* with respect to affect relations" (p. 54, italics added).
> "Complete connectionness is every two components *directly* channeled to each other with respect to affect relations" (p. 54, italics added).
> "Wholeness is components which have channels to *all other* components" (p. 58, italics added).
> "Integrationness is [maintenance of] wholeness under system environmental change" (p. 58, brackets added).
> "Vulnerableness is some connections when removed produce disconnectivity with respect to affect relations" (p. 56).
> "Disconnectionness is not either complete connectedness or strongness or unilateralness or weakness and *some components are not connected* with respect to affect relations" (p. 55, italics added).

In particular, the notion of increasing system *complexness* is the foundation for the definition of *learning* in TIE theory (Frick, 2018; Educology, 2019). The notion of *forgetting* is defined as decreasing system *complexness*, i.e., some connections are broken and no longer exist. Also influential in the development of TIE is Thompson's Axiomatic Theory of Intentional Systems (2006). See https://aptac.sitehost.iu.edu/glossary/atisTheory.html. ATIS more precisely defines many SIGGS properties and further extends Maccia and Maccia's earlier work. While SIGGS was originally used when developing their education systems theory, we are focusing on a learner's human nervous system in this article while using many of Maccias' and Thompson's systems concepts.

Most importantly, the central ideas in TIE are system *wholeness* and greater *flexibility*. When each component has two or more connections to every *other* component, it follows that such a network is less *vulnerable* when compared to a weakly or unilaterally connected network. That is, when some connections are broken, *wholeness* of long-term memory can still be maintained. Furthermore, completely-connected component sets should provide greater *flexibleness*, i.e., because many different pathways exist between individual components. As an analogy, think of a spider's web–when nodes are highly interconnected, small tears in a few places will not destroy the whole web, and allow a spider to make quick repairs.

Therefore, to the extent *wholeness* among component sets is maintained or increased, then *vulnerableness* should decrease–forgetting of what has been learned is less likely. Thus, the TIE prediction is that learning activities which increase *wholeness* in student mental structures should be more effective with respect to student learning (and not forgetting). Totally integrated education should maximize *strong* connections among kinds of knowing (cognition), intention (conation), and feelings (emotion). Student learning which occurs during totally integrated education should result in more stable long-term memory, less likely to be forgotten as time passes. Recent research findings in neuroscience which explain how learner minds emerge from formation of complex neural networks are consistent with TIE predictions (Bertolero and Basset, 2019; Eagleman, 2015)

For further definitions and examples of TIE terminology, see the Educology Website (2019) at: https://educology.iu.edu/.

TIE is intended to help students form mental structures which integrate cognition, intention, and emotion through grounded real-world experiences. Figs. 1, 2, 3 and 4 represent cognitive, conative, and affective levels to be integrated when designing learning activities that are based on TIE.

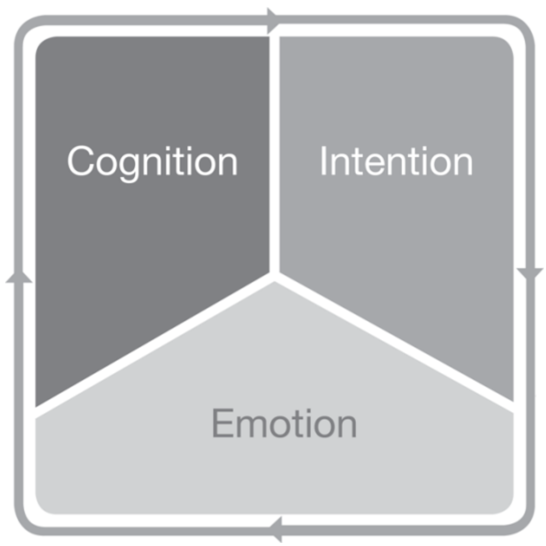

Figure 1. Schema for desired connections among a student's cognition (thinking), intention (willing), and emotion (feeling) during a learning activity (graphic by Colin Gray). Reprinted with permission from Frick, 2018.

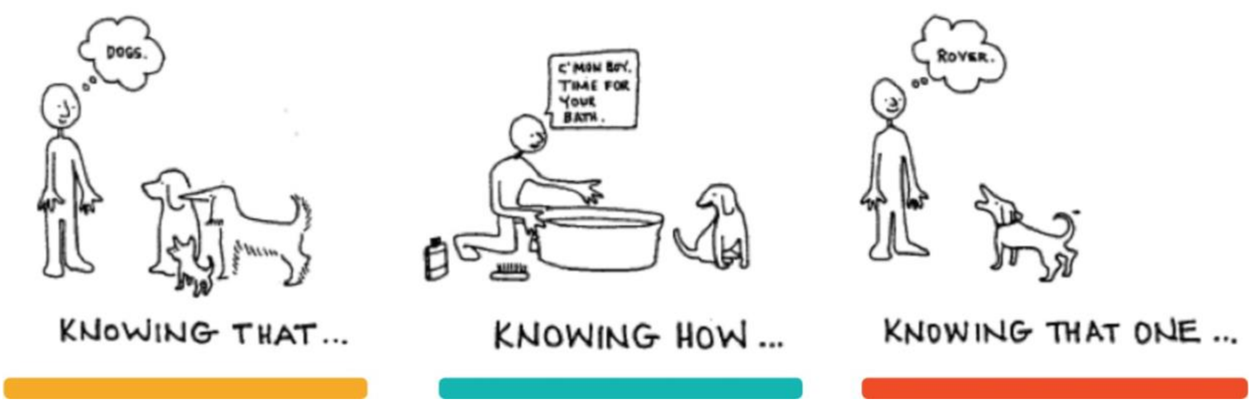

Figure 2. Three basic kinds of cognition (drawings by Elizabeth Boling). Reprinted with permission from Frick, 2018.

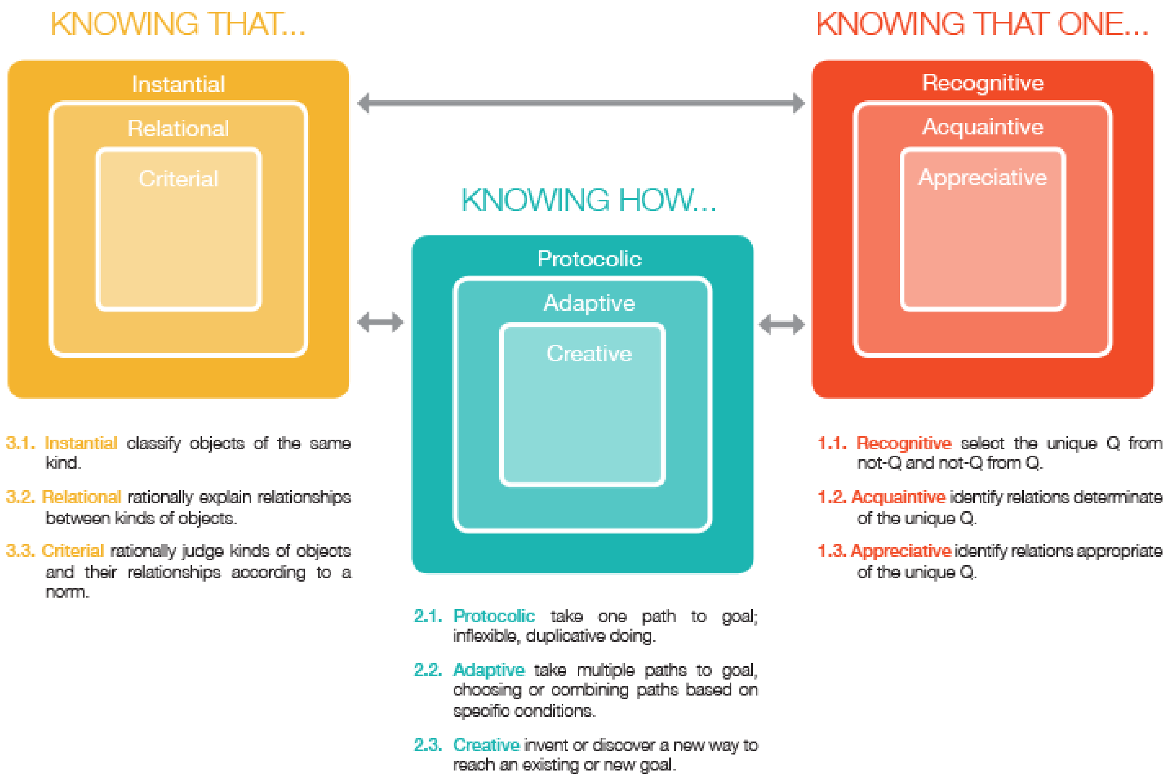

Figure 3. Illustration of integration of 9 kinds of cognition. The shading of areas indicates presence of components, and the nesting of areas represents subset relationships (connectivity). The double-headed gray arrows represent connections among the 3 basic kinds of knowing, which are respectively color coded. Graphic by Colin Gray and Theodore Frick. Reprinted with permission from Frick, 2018.

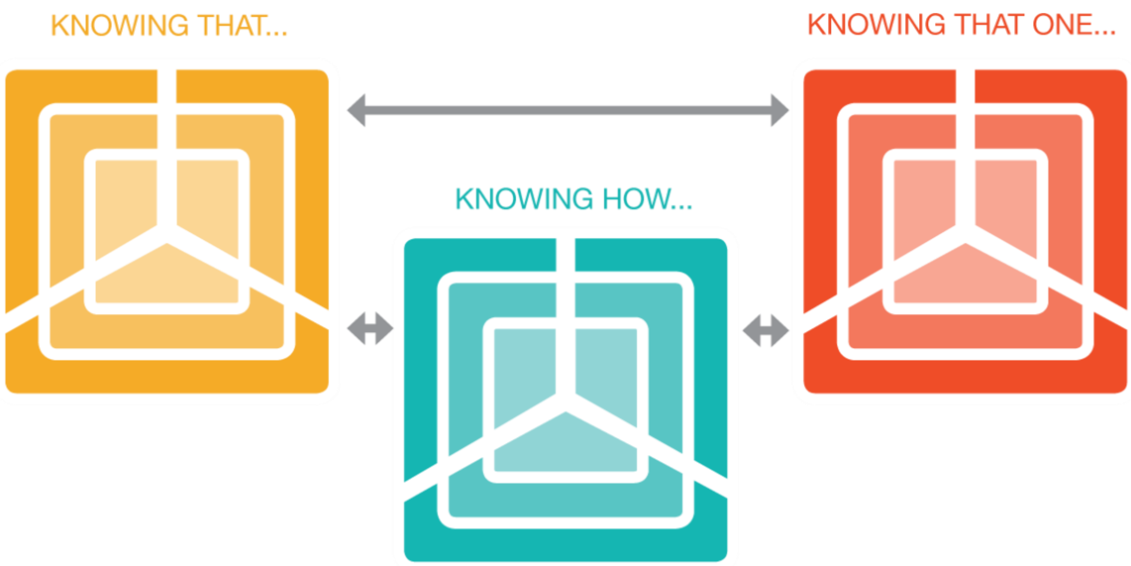

Figure 4. Illustration of a totally integrated mental structure, where cognition, intention and emotion are completely connected with respect to an object of knowing (e.g., a dog). Figures 1-3 are in essence combined visually. Graphic by Colin Gray and Theodore Frick. Reprinted with permission from Frick, 2018.

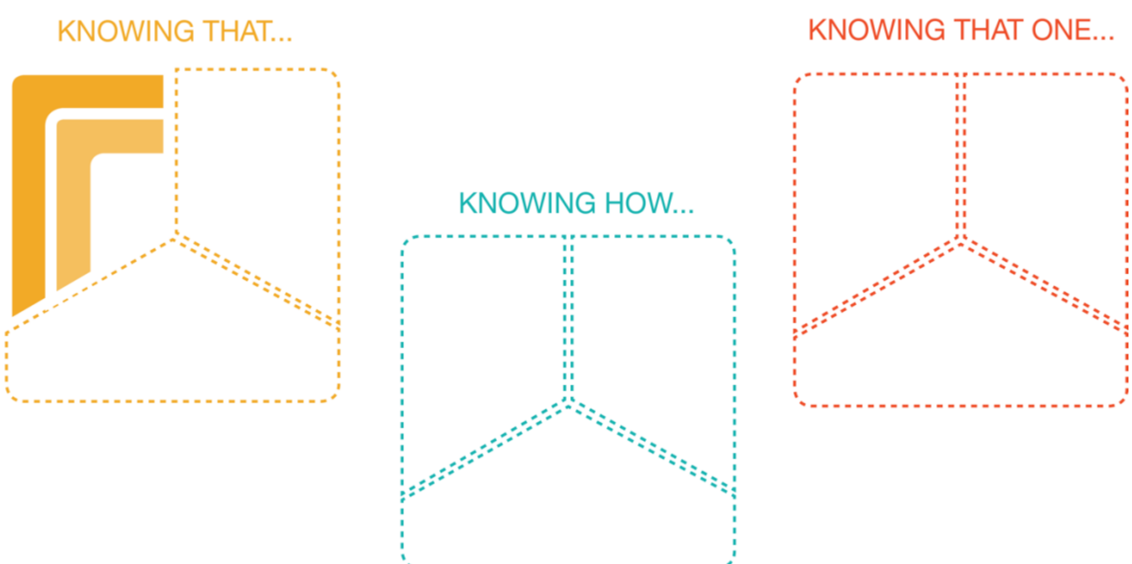

Figure 5. Illustration of a weak and highly disconnected mental structure. Components are mostly missing and disconnected with respect to a given object of knowing (e.g., a dog). Unshaded areas with dashed borders indicate those components are missing. Moreover, the three basic kinds of knowing are disconnected, represented by *lack* of gray arrows. Compare with Fig. 4. Graphic by Colin Gray, reprinted with permission from Frick, 2018.

Note that in Fig. 5, 18 components of *knowing how* and *knowing that one* are missing, disconnected from each other and from *knowing that*. Furthermore, within *knowing that*, 6 components of student intention and emotion are missing from this mental structure (with respect to an object of knowing), which are represented by unshaded areas with dashed borders. This kind of ungrounded and dissociated learning can occur when signs used in communication are used in isolation from their corresponding real-world objects and purposeful activity. The resulting mental structures are weakly connected, lacking wholeness and integration. Unfortunately, the weakly connected mental structure illustrated in Fig. 5 is typical of those formed by students during numerous classroom learning activities in American school systems.

Examples of Totally Integrated Education in Practice

We propose to provide several positive examples of existing education programs and curricula which illustrate totally integrated education.

As one example, the Unionville Elementary School in Bloomington, Indiana, USA, has developed a unique curriculum they identify by the acronym EARTH: Environment, Art, Resources, Technology and Health. Howell (2018) reported in a local newspaper article on the Unionville School:

> You can see it when you stop by the school: Trays full of seedlings sprouting on classroom windowsills. Potatoes growing roots in cups of water. Large shelves bearing gardening tools and seed packets near the back door. Teachers and students holding class outside, on the hill, by the garden boxes, under the sheltered "learning lab" on the playground and in the miniature amphitheater with wooden benches by the pond. Students planting flowers and vegetables, or watching and sketching the trees, writing their observations in science notebooks. (paragraph 2)

Howell further reported:

> In many ways, the curriculum harnesses things Unionville has been doing for years. They compost and recycle in the school cafeteria, use the outdoor spaces often and go for hikes on Unionville's 18 acres. The fishing club catches fish in the school's pond from a little dock built for class purposes. They use different kinds of art, including quilting, to visually represent what they're learning. The school teaches digital citizenship and coding, as well as healthy living and good lifestyle choices.
>
> EARTH puts a renewed focus on those elements, increases the number of science experiences and puts an outdoor, environmental twist on it all. (paragraphs 7-8)

Howell quoted the Unionville principal, Lily Albright, who said, "It's about appreciating and understanding what's going on right here in our own backyard, and applying that as we think about the world and our place in the world" (Howell, 2018, paragraph 9).

The EARTH curriculum is clearly intended to help guide Unionville elementary students to connect *knowing that*, *knowing how,* and *knowing that one* (see Figs. 1, 2, 3 and 4). It illustrates a practical implementation of TIE in this particular context.

We propose to provide further examples of TIE in addition to the Unionville Elementary School EARTH program: the Bloomington Montessori School; and SUNY Cobleskill programs in Fisheries, Wildlife and Environmental Sciences; Fermentation Science; Biotechnology; and Graphic Design.

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