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Authors who wish to have articles considered
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Elan Safit

It is with great pleasure that I am introducing here the current issue of the *Research Bulletin*, the first for me as incoming editor. As a former Waldorf high school English teacher, who proceeded to teach philosophy and literature at the college level, I have never lost my connection with Waldorf education and anthroposophy, so I am delighted to resume more formal ties through the post of editor of the *Bulletin*. I would like to extend my gratitude to the outgoing editor, Elan Leibner, and to Douglas Gerwin, for doing much of the preparation work for the current issue, as well as to Patrice Maynard and Ann Erwin, who helped initiate me into this new role.

This issue continues, though by no means concludes, the ongoing conversation regarding the theme of technology, around which the previous two issues were centered, as well. In this context, several of the articles published here are final installments of three-part essays launched in the Autumn/Winter 2016 issue of the *Bulletin* (Vol. 21-2).

The current issue opens with a transcription of the keynote speech that the chairperson of the Pedagogical Section Council of North America, Elan Leibner, recently gave at the 2017 AWSNA Teachers Conference in Portland, OR. Asked to talk about AWSNA's Core Principle #7, which calls for cultivating an anthroposophical understanding of social interactions in the self-administration of Waldorf schools, Leibner begins by reflecting on the nature of "an anthroposophical understanding" of the social and practical interactions of a faculty meeting. Leibner's important insight is that "*spiritual beings interpose themselves between us as we meet.*" He continues his reflection through dialogue with Rudolf Steiner's designations of the evolution of the human Self, reaching, finally,

the archetype of the human capacity for love. This Love Impulse Leibner names AHAVA, the acronym for "Archetype of Human Amity, Verity, and Altruism" and also the Hebrew word for *love*. The article concludes with practical suggestions for employing AHAVA, or the Love Impulse, in Waldorf schools, in both the classroom and the self-administration of the school.

Jason Yates offers the third and final installment of his exploration of a digital mode of thinking, or a "digital gesture," as that which gives rise to technological invention. Proceeding further from the roots of technological invention to its production and transmission of images, Yates asks, What is an image? and follows the thought of French philosopher and theorist, Jean Baudrillard, who provocatively claimed that the real has been dissolved under the weight of the images that replaced it in the late 20th century. In order to recover a sense of reality, Yates recruits the German philosopher, Martin Heidegger, whose approach was characterized by an endeavor to allow the truth of being to reveal itself from underneath practical aspects, such as the ones of technology, that tend to "enframe" reality in their own practical terms and thus conceal its original and enduring meaning.

Gopi Krishna Vijaya concludes his three-part investigation into the historical split between human thought and the mathematical-mechanical model of thinking that gave rise to computer "intelligence." Vijaya's exploration, which began with the emergence of Western logic, mathematics, and geometry in ancient Greece, shows how, with the modern era's developments that have produced the computer, a logical-mechanical model of thinking threatens to overtake the wider, richer, creative aspects of human thought. Vijaya's conclusion is worth

quoting here: “When it is accepted that this form of machine-logic is a small subset of the full range of capacities of the thought process, then it would be possible to prevent harm and actually use it for relieving the mind of rote repetitive work.”

Harlan Gilbert, who published his reflections on computers and intelligence in the previous issue of the *Research Bulletin*, teamed up with Jennifer Mankoff, a Waldorf-educated professor of computer science at Carnegie Mellon University. The two authors offer here outlines and a wealth of resources for 5th through 8th grade lesson plans designed for exploring conceptual and practical aspects of computer programming and use.

Charles Weems follows up his article on introducing computer science in the Waldorf high school (*Research Bulletin* 22-1, Spring/Summer 2017) with this helpful elaboration of a CS course for 11th graders. Shot through with practical examples of classroom assignments and explanations about how some aspects of the internet work, Weems’ article follows Steiner’s dictum about the need to understand fully our interactions with the technology that takes an increasing role in our daily lives.

Helen-Ann Ireland offers an illuminating discovery in her article. She shows how a current leading pedagogical theory, devised by Professor Howard Gardner of the Harvard Graduate School of Education, neatly corresponds to what Waldorf teachers have been doing in their classrooms for decades.

The articles section of this issue concludes with an expanded version of a talk I gave last spring at the Green Meadow Waldorf School. This talk was about the future of Waldorf schools in terms of the two great challenges that are already upon us in the present: namely, coming to terms with the ubiquity of modern technology and addressing the ongoing and anticipated environmental transformations that are set to change both physical and social living conditions on the planet. A future-oriented education system such as Waldorf, I conclude, should

prepare its students for their future challenge of securing livable conditions for an ethically committed society in a transformed world. Such a challenge would necessarily involve a thoughtful engagement with advanced technology by directing its tools toward preservation and protection in order to reverse the harmful effects of the thoughtless use of technology that has brought us to this point.

With this final article, we wish to continue the discussion of technology by channeling it further into the question of environmental or ecological transformation in the context of Waldorf education. For this purpose, we would welcome submissions of articles and book reviews that address this theme.

As always, we conclude with reports from the world of Waldorf Publications and from the Online Waldorf Library offered by Patrice Maynard and Marianne Alsop, respectively.

I trust and hope that many Waldorf educators and other interested parties will find both reflective and practical uses for the articles collected in this technology-themed issue, the impulse for which can be found, perhaps retroactively, in Steiner’s lecture on aesthetic education:

Anyone who uses products of modern technology without having any knowledge of how they work or of how they were made is like a person in a prison cell without a window through which he would at least be able to look out into nature and to freedom.

– Rudolf Steiner, *Soul Economy and Waldorf Education*, CW 303, “Esthetic Education,” Lecture 14, January 5, 1922 (Spring Valley, NY: Anthroposophic Press, 1986, 243).



From the Executive Director

Douglas Gerwin

With this issue, we introduce to you Ilan Safit, PhD, the new editor of our *Research Bulletin*. Like his predecessor Elan Leibner, Ilan comes to us from Israel but has spent much of his adult life in the United States.

For two years, Ilan taught humanities in the high school of the Rudolf Steiner School in New York City, but most of his career to date was spent in the world of professional writing and university teaching. For the past two decades, Ilan has taught a wide range of subjects in the humanities at SUNY Stony Brook, Pace University, Queens College, NYU, and the State University of New York at Buffalo, where he earned his MA and PhD in comparative literature. Currently, he holds the position of Visiting Scholar in the German Department of New York University. Ilan had also earned a Master's degree in Film and Television Studies from the University of Amsterdam.

While teaching at the college level, Ilan was simultaneously chief editor for ten years of *Yediot Aharonot America*, a weekly magazine and website for Israeli émigré communities in North America, for which he also wrote stories and reviews, as well as a regular op-ed column. In this context, he brings to his latest assignment at the Research Institute broad experience as writer, editor, lecturer, and commentator on contemporary cultural issues.

In 2009, Ilan launched the Center for Ethical Thinking at Pace University, an academic center dedicated to promoting discussion of contemporary social, political, and environmental issues from an ethical perspective. Among the titles of the symposia he organized at the Center—telling indicators of the breadth of his interests—were “Thinking Ethically,” “On Education,” “On Islam,” “The Other 9/11,”

“Representations of Violence,” and “Welcome to the Political Circus.”

Ilan's study of anthroposophy and Waldorf education, which started during his undergraduate days at Tel Aviv University, eventually took him to Holland (where he met his wife, a Waldorf graduate) and then to the United States. His reflections on the future of Waldorf education are included in this issue of the *Research Bulletin*.

In taking over as editor of the *Bulletin* from Elan Leibner, who has returned to class teaching at the Kimberton Waldorf School, Ilan joins a circle of colleagues at the Research Institute deeply involved in the world of publications and media, including Patrice Maynard (Director of Waldorf Publications and Development) and Marianne Alsop (who oversees our Online Waldorf Library, or OWL). Patrice and Marianne report later in this issue on their work, including the release of new titles as well as a selection of articles and books in electronic form—a growing number of them in Spanish and the first few of them in Mandarin translation.

Ilan will also be involved in the later stages of a wide-ranging survey of North American Waldorf graduates recently launched by the Research Institute under the guidance of Liz Beaven and now being managed by Connie Stokes. The survey—which will focus on the most recent 25 years of alumni from the 40 extant Waldorf high schools across North America—is slated to be released in time for the centenary of Waldorf education in the 2019–2020 academic year.

We are delighted to welcome Ilan onto the team of the Research Institute!

Between Our Demons and Our Gods

Human Encounter in the Light of Anthroposophy

Elan Leibner

This article is based on a keynote lecture given at the opening of the 2017 AWSNA Teachers Conference, held at the Cedarwood Waldorf School in Portland, OR.

When Melanie Reiser, AWSNA Executive Director for Membership, asked me if I would speak at the opening of this conference, she read me our Association's Shared Principle #7. It begins with the words: "Waldorf schools are self-administered. This work is strengthened by cultivating a shared anthroposophical understanding of social interactions." She said, "Talk about what that means."

My mind quickly turned to my earliest days as a Waldorf teacher. There were two teachers in the school I joined, and every week during the faculty meeting a strange ritual would unfold: Some topic or other would be up for discussion; sooner or later, one of the two would take a stand, usually in strong, confident words. With the predictability of a Swiss watch, the other would take the opposite point of view. It didn't matter whether we were talking about a specific child, planning a festival, or debating where teachers should park their cars in the morning. Sometimes it seemed that one of them would try to take the point of view that the other usually espoused, as if to make nice. No matter: The other would contradict his usual approach just for the occasion, as if saying, "I usually stand for X, and you stand for Y, but today, since you suggest X, I must advocate for Y." It became clear to me that the topics were not really what mattered; rather, it was the encounter

between these two that had its own gesture. The consequence of these weekly debates was that the meetings often felt both predictable and exhausting. I would even say predictably exhausting. I would like to leave this little image, surely one that is not entirely unfamiliar to many of you, as an example of one kind of encounter.

The other example I want to present is from a College of Teachers meeting I attended several years later. The purpose of the meeting was to review the work of the College during the previous school year. A colleague said something deeply significant: "Two things really strike me about our meetings: The first is that they always surprise me. We find new ideas and solutions that no one seemed to have had when the meeting began, and I personally often leave feeling that I have more energy than I had when I came in." So that's a different kind of encounter, with radically different results. I would like to posit that surprise, in the good sense, and renewed energy are two hallmarks of the encounters we should foster.

Back to Melanie and Shared Principle #7: I pondered the wording, particularly the "anthroposophical understanding of social interactions." It struck me, eventually, that anthroposophy has one essential contribution to make to the study of social interactions. It is strikingly simple to articulate: Spiritual beings interpose themselves between us as we meet. Whatever techniques, practices, policies, and structures we can find helpful from the world outside Waldorf education, this essential insight will always form a dimension that must be taken into account.

Anthroposophy has one essential contribution to make to the study of social interactions: Spiritual beings interpose themselves between us as we meet.

Spiritual beings interpose themselves between us as we meet.

Mainstream psychology and sociology books that have looked into the area of social interactions have not been able to explore this possibility, and for three reasons: first, because the requisite conceptual framework that would allow for this contribution is missing. Therefore, second, the language that would allow for an articulation of insights is missing or ignored. And third, the capacities that are needed for meaningful research to unfold are nowhere to be found, since no one recognizes that they are needed in the first place. In other words, given that spiritual beings are not acknowledged in the mainstream, they do not enter its conceptual framework, its terminology, or its tools of research and analysis.

When we undertake the task of leading an organization as a team, clarity about, and a conscious cultivation of, the relationship with spiritual beings is an ever-urgent pair of challenges. We will first look at the historical development of our relationship with certain spiritual beings and then consider a few suggestions for cultivating healthy human encounters in light of the presence of those beings.

Soul Encounters as a Particular Challenge

The image of the human in anthroposophy is of a threefold being: body, soul, and spirit. I will focus here solely on the second aspect of the human constitution, namely the soul.¹

Because they are often entangled in a web of emotions, difficult soul encounters challenge us in ways that can feel overwhelming and insurmountable. They lack the clarity of spiritual principles, and so remain nebulous, yet they carry a powerful surge of emotional intensity.

Rudolf Steiner describes two phases in the relationship of the “I”, the Self, to the lower members of the human constitution. The first phase entails an unconscious, the second a conscious set of transformations. The first phase

produces an elaboration of the lower members (developed for us by spiritual beings) into three soul layers. The second phase produces three layers of spirit. I would like to briefly describe the stages of the first phase and to characterize the resulting soul layers. In anthroposophical nomenclature, all of these layers have particular names. My language here, to the extent possible, will avoid these names in favor of signature gestures, by which I mean the activities that most characterize each layer. My intention is not to deny the validity of the usual terminology, but to encourage both you and me to avoid familiar words that we, often too easily, assume we understand, perhaps more than we actually do.

Historical Context

At the outset of the transformational process just mentioned, the human constitution includes three facets that Rudolf Steiner called the physical, etheric, and astral “bodies”; I should note that the English translation “body” for the German *Leib* can be problematic in discussing the etheric and the astral, since they lack obvious physical characteristics. (The German *Leib* is not as problematic, given that its original signification is less grounded in the corporeal—the way the word used in relation to the animal and human body, *Körper*, is; *Leib* is closer to the use of “body” in English in expressions such as “body of knowledge.”) The first is a physical body. We can think of it as the material level that we share with all mineral, living, and sentient beings. The second is the life body, which we can think of as the level we share with living organisms that grow and reproduce, namely plants and animals. The third Steiner called the astral or soul body. It is the level we share with all sentient beings, namely animals. Its signature gestures are movement, both inner (as in a response to stimuli and circumstances) and outer (autonomous displacement that plants cannot achieve). Another way of saying this is that beings endowed with an astral body exhibit some degree of consciousness.

When the human Self, or “I,” was introduced into the evolution, it began interacting with these existing bodies. These interactions were initially completely unconscious. And although they have produced increasingly conscious results, as we shall see, these interactions only recently began, themselves, growing more wakeful within us.

The Desiring Soul; The Spirit of Fun and Freedom; Illness, Suffering, and Pain

At first, during a period that Rudolf Steiner calls Lemuria, the Self began interacting with what we have termed the astral body. Merely instinctual, animal-like responses to stimuli grew more individualized. People could begin to like and dislike aspects of their environment in ways that differed from their peers. Rudimentary personality traits began to emerge.

At this point, an important spiritual intervention took place. Up until then, only benevolent spiritual beings were involved in earth evolution. But now, adversarial spiritual beings at a level equivalent to what Western traditions call angels developed a different relationship with humanity. Collectively, we can refer to these spirits in the singular as The Spirit of Fun and Freedom. Genesis depicts it as the serpent; elsewhere it is called the Devil, or Lucifer. It introduced the possibility of error into human conduct. The result was, on the one hand, a greater level of separation of humanity from its divine origins, and therefore freedom for the individual human being; and, on the other, the development of desires, cravings, and lust for sensations.

It was the first elaboration of the human soul—we can call it the Desiring Soul. Think of the moment when you meet a person and feel either an irresistible desire or an equally strong repulsion toward that person. On a more trivial level, you open a catalogue that just arrived in the mail, or surf a commercial website, and suddenly you cannot live another moment without owning an item that five minutes earlier you did not even know existed. Or you see

something that someone else has and you really, REALLY want it.

An important characteristic of the Desiring Soul is that it is inherently insatiable. No amount of goods, food, or pleasure is ever enough for more than a brief interval of time.

In order to mitigate the results of what The Spirit of Fun and Freedom wrought, the benevolent spiritual forces had to introduce illness, suffering, and pain into the life of humanity, so that we would not utterly succumb to the temptations of the senses. This may sound cruel to the modern mind, but we can also think of it as being given the opportunity to learn to live with consequences. Other terms for that are growing up or maturing. Like a young person coming into adulthood, one has to learn there is a price for bingeing on anything, and sometimes even for trying just a little taste. A hangover after a night of drinking is one common example of how our desire for sensations can result in adverse consequences. Addictions of all kinds provide more examples.

The Explaining/Planning Soul; The Spirit of the Machine; Karma

The next step in evolution involved the Self penetrating and unconsciously transforming the life body. This took place in the period that Steiner terms Atlantis. Living organisms grow in regulated, law-governed ways, which shows us that there is an intelligible pattern governing their life cycles. This pattern is coded, so to speak, into the life body. When the Self finished “working through” the life body, the result was a second layer of soul, one that we can designate The Explaining or Planning Soul. To get a feeling for it, we can imagine that the Desiring Soul wishes for some item or experience. It is the role of the Planning Soul to figure out how to satisfy the wish of the Desiring Soul. For example, we can plan on buying this item, stealing it, or killing our neighbor in order to get it. All three would achieve the desired result, and for the Planning Soul there isn’t yet a particular preference for

one over the other, except expediency. In the realm of knowledge acquisition, the Explaining Soul does just that: It explains things, which means replacing mysterious phenomena (e.g., nature's) with models that are easier to comprehend. The entire edifice of natural science is the glorious, and problematic, triumph of the Explaining Soul, essentially replacing the mysteries of nature with mathematical formulations. It is immensely satisfying to feel that we know what something "really is," even if, for example, we are not much closer to understanding the nature of pleasure when we say that pleasure "really is" nothing but the body secreting certain hormones (e.g., serotonin, oxytocin, or dopamine).

We have just turned our gaze to where the street lamp is lighting a section of the sidewalk, even if it isn't where we lost our keys, or at least not most of them. Still, we are left with the satisfying illusion of knowing. In effect, we have translated the world into the language of mathematics, and now a blind person can understand color just as well as a seeing person, because "color really is nothing but an angle of refraction, or a wavelength, that can be expressed mathematically." The same goes for all the other senses and their sensations, and even for consciousness itself. We think that we have explained the senses, but in reality we have only explained them away. The world disappears, and all that's left is math.

When the Explaining/Planning Soul came into being, there was a second intervention of spiritual beings, this time of the adversarial level equivalent to that of the archangels. We can name them, in the singular, The Spirit of the Machine. The Persians, as well as anthroposophists, name it Ahriman. Others call it Satan. Initially, this spirit's influence led to the possibility of what we call sin. Sin differs from error in that the former is deliberate. Human beings could now know in advance that they

were violating the intended order of the universe. A second consequence of the presence of the Spirit of the Machine was that knowledge of the spiritual origins of existence was gradually lost, and people could no longer see beyond the senses. We can appreciate, therefore, how materialism could develop.

To mitigate the influence of the Spirit of the Machine, the benevolent forces introduced death and the law of karma. We shall return to death a little later. But karma is really a wonderful thing! We usually think of it as the source of all manner of difficulties, but we should be eternally grateful that it exists, for it allows for the balancing of sins. Imagine if your sins were written into your being in such a way that it would be impossible

to make matters right. Next time you find yourself in a karmic knot, be glad and thankful for it. You may not be able to untie it yet, but at least you have the opportunity to try.

The Understanding/Empathetic Soul; The Spirits of Darkness; AHAVA

The third chapter in the Self's unconscious transforming of the lower members was its penetration of the physical body. It is still ongoing and has been bringing a third soul facet into existence. This facet we can designate the Understanding or Empathetic Soul. Its chief attribute is that it can serve as a moral compass. In the example I gave earlier, the Planning Soul can find different ways of satisfying the cravings and wishes of the Desiring Soul. How would one choose which of these ways is best? For the materialistic-thinking Planning Soul, expediency is the only arbiter. But what of ethics? If the Planning Soul can say, "true or false, fast or slow," the Understanding Soul can tell, and FEEL, the difference between good and evil. It is the soul that can understand, rather than merely explain, and that can empathize with another human being. After the increasing distance from the

We think that we explained the senses, but we have really only explained them away. The world disappears, and all that's left is math.

phenomena that the Desiring Soul and Explaining Soul have produced, the Empathetic Soul can re-connect with phenomena, this time without disappearing completely into a dreamy or sleepy state of consciousness. “I” can understand “you,” rather than merely feeling attraction or repulsion, as with the Desiring Soul, or explain you (using extrinsic measures) to myself, as with the Explaining Soul.

There is also a third intervention of adversarial spiritual beings that is beginning, and this one has a particular twist. These beings are the adversarial equivalents to the spiritual hierarchy designated in Christian esotericism as the Archai. While the benevolent Archai bestowed the Self on humanity, these adversarial counterparts work in precisely the opposite direction. They encourage human beings to divert the understanding capacities (which the Self has been developing) in order to manipulate others in purely egotistical ways. Sociopathy and psychopathy are examples of this type of action, and orgiastic behaviors, for example, point toward a future in which some people will gear their entire lives toward incessant sensual pleasure. The sociopath has a keen understanding of others, but does not care about their wellbeing. The psychopath is similarly insightful, but goes even further by actually enjoying the pain he can inflict. The twist in the narrative here is that, according to Rudolf Steiner, the benevolent spiritual powers cannot help us find redemption for acts committed under the influence of these new adversarial forces, which he names (using an old term for the Archai) the Asuras; every time we choose the path of pure egotism, a sliver of our divine Self is lost to darkness. This is a new reality in human evolution, and means that we are now increasingly capable of self-annihilation. It is darkness, the likes of which humanity has never encountered before.

[I]f human beings take this Love Impulse into themselves, it will ... condense into physical light until the earth will become a new sun.

But where a great darkness appears, a great light must also be present. This light I would like to designate AHAVA, the acronym for “Archetype of Human Amity, Verity, and Altruism.” Conveniently, AHAVA means “love” in Hebrew, and we can think of “the archetype of the human capacity for love” as another name or designation for AHAVA. I will use “the Love Impulse” to describe what AHAVA is trying to help us develop. Rudolf Steiner referred to it, in a term that was less problematic for his milieu than it is for our time, as the “Christ Impulse.”

According to Steiner, there was a moment in history when AHAVA joined the earthly, human stream of being for a brief period. It penetrated the lower sheaths, or bodies, of a human being and, as a human being, shed blood into the earth as it died. This love-infused blood turned into life forces (ether), and the earth itself began, for the first time, to radiate light into the cosmos. AHAVA moved its sphere of action into the sheaths surrounding the earth, and the light associated with Love began radiating as the earth’s own emanation. This light was not yet physical, but if human beings take this Love Impulse into themselves, it will increasingly condense into physical light until the earth itself will become a new sun!

The Etherization of Blood and the Love Impulse

As if the idea of helping to make the earth into a new sun is not inspiring enough, Rudolf Steiner also says that every human heart turns a portion of the blood that passes through it into a fine stream of life (or etheric) forces that flows upwards into the head. When human beings take up the Love Impulse into themselves, the individual stream of etherized blood joins the etherized stream of the Love Impulse, and completely new capacities can arise in the soul. Those capacities are key elements of any

potential progress for humanity, and, I suggest, for the potential survival and success of Waldorf schools. They entail, among other things, direct perception of spiritual realities and an ability to act out of the highest moral ideals.

Human Encounter on the Three Levels; Proposed Practices

Thus far we have surveyed an evolutionary process and followed the appearance and influence of various spiritual beings, both benevolent and adversarial. It is time to “get down to brass tacks,” as the saying goes: What can we do in a school context in order to facilitate healthy human encounters,

knowing that our demons and our gods, as my title suggests, are both eager for our cooperation?

I would like to take each of the three soul facets, or members, characterize its typical appearance in human relationships, and propose an approach that concentrates on the elements that promote health and wellbeing—in other words, a salutogenic approach.

The Desiring Soul

The two archetypal gestures of the Desiring Soul are attraction and repulsion. A new colleague or parent comes into view, and one feels a strong attraction toward this person, or perhaps a strong revulsion. In our culture, it is not acceptable to express these sentiments. I don’t think that school communities would benefit if they encouraged verbal expression of the animal-level desires and revulsions that we might feel toward one another. The point here is not to externalize what might ordinarily be expressed only in anonymous online chat rooms. There are not only humane grounds for restraint, but legal ones as well.

However, simply suppressing the lower impulses of the Desiring Soul is not a good practice either, if it remains the only thing we do.

Suppression leads to repression, and repression leads to illness. You can sit in a faculty meeting and find yourself wondering why on earth tensions run so high when the topic is seemingly so banal. The same two or three individuals seem intent on clashing with one another regardless of the topic, as in the example with which I started. The opposite can also happen: People agree with one another based on sympathy, or even attraction, and yet the root of their agreement is not the topic at hand or the wellbeing of the school. When people manage to sublimate their attraction and repulsion completely, physical and/or emotional illness can arise. We don’t overcome

a lower aspect of ourselves by pretending it does not exist.

In short, the two extremes of repression and expression are not healthy for us, nor for the school. What I would like to suggest is that there is a way of processing the impulses of the Desiring Soul, a way that can be healthy. By this

I mean engagement with the arts, specifically in what I would call chamber arts: eurythmy, chorus, speech chorus, drama, music making, and so on. There is a whole field of artistic endeavors, some extant and some waiting to be developed, that would allow teams to work through the impulses of the Desiring Soul so that beauty can emerge out of the process. Since the Spirit of Fun and Freedom is also a key inspiration for artistic creativity, we would be using this Spirit’s gifts to neutralize his malevolent influence!

An essential benefit of chamber arts is that they provide a strong impetus for recognizing the spiritual in our fellow human beings. Artistic processes, when done well, move people through obstacles and long-established patterns, and allow them to grow. When we witness someone growing, we know that we are in the presence of a “human becoming” entity. This experience should always leave us hopeful: What is problematic today may change in time. As long as we are hopeful, progress is possible.

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The main problem with our patterns of desire and revulsion is that, especially with the latter, we assume permanence. But when our “enemy” has overcome an artistic blockage or, better yet, helped us overcome one of our own, a layer of enmity is shed. Over time, sufficient layers can be shed so the two of us can see the better aspects of each other that were previously hidden from our view. Real conversations, verbal or through correspondence, are another way of overcoming these impulses. They are seeds of the future social art of conversation. A striking and very moving example is the late-life correspondence between Thomas Jefferson and John Adams.

In short, I would like to throw down something of a gauntlet here to my art-teaching colleagues: There is a whole field of exercises that you can develop to help teams healthily process the lower impulses of the soul.

I want to be clear that individual artistic work can also be helpful. I have written a lot of poetry to process my life’s events. But individual work helps an individual. Chamber work helps those who are in the chamber, which, in the context of the current discussion, is the relevant group within the school. But another aspect of its efficacy is that it invites the spiritual beings that support harmony and collaboration to be active for the duration people strive together artistically.

The Planning/Explaining Soul

The signature gestures of the Explaining Soul have in common that they are past-oriented and replace genuine encounter with analyses and prescriptions of all kinds. Because the birth of the Explaining Soul was accompanied by the possibility of sin, schools and organizations have introduced “sin prevention” programs: policies and procedures! This leads to a safer environment, but also to a stilted and warmth-less one. Every bureaucrat says, “That’s the policy. I did not make it, I just administer it.” The policy was no doubt created because someone did something that had the “flavor” of sin, therefore having some kind of justification for it.

I am not suggesting that policies and procedures have no place in a school. But they do present a new kind of challenge by introducing general rules for all, thereby limiting activities of the human being as an individual and handling complex realities with a one-size-fits-all approach.

A second common gesture of the Explaining Soul is the dissection of another person by the use of psychoanalytic language. This language is invariably past-oriented. Parents or food or some trauma are held responsible for something that a person did or for the way he or she is behaving. Again, there may be some justification for this approach, but it comes with the danger that we distance ourselves from the other, and most importantly that we feel superior to the other. Since we think we know why she behaves in this particular way, we can respond with empathy, but all too often we adopt the self-congratulatory mood of seeing the other “from above.”

I would like to suggest three practices that can help us work with the gifts of the Explaining Soul in order to neutralize its deleterious effects:

1. The first is enlivened study of inspired texts. The hallmarks of enlivened study are that it is experiential, context-rich, and deed-oriented. When we merely read a text in a faculty meeting, the effect is minimal and sometimes even negative. Study is best begun by bringing in an experience; just as we know from the classroom that beginning with the will and proceeding through feeling to thinking is the best way to go, so also in the faculty study.

Healthy study is also context-rich. It arises out of and, in turn, creates context and relationships. Anything, even an anthroposophical concept, studied in isolation is a lie. For example, the cultural, political, and location-specific circumstances of Steiner’s lectures are important; we can also follow up a reading with a discussion of how the themes he develops may need to be articulated in terms of our own circumstances. It is inconceivable to me that Steiner would be saying the same things in the same language a

hundred years later. He was the consummate innovator and revitalizer of culture; how would he have developed his themes in light of what has transpired since he first brought them forth?

Finally, study should be deed-oriented. We should ask ourselves: What is indicated by this study for our work? How do we translate the inspiration of the text into action?

2. The second practice or “cure” for the Explaining Soul is a study of nature as a text. For example, the works of two of our colleagues, Craig Holdrege and Dennis Klocek, demonstrate instances of research into the meaning of natural phenomena.² When we seek for meaning, as opposed to explanation, we learn to read nature as a text. A text implies a creative force, an author, and this sense helps us overcome an ailment that the Spirit of the Machine has infected us with: the estrangement from our divine origins.

3. The third “cure” is the study of projective geometry. The Explaining Soul typically traffics in mathematical explanations that replace phenomena with numbers. Projective geometry is a mathematical field that requires imaginative capacities if it is to be understood. It is, if you will, the redemption of our relationships with mathematics. It begins with familiar geometric notions, but quickly moves into dimensions that must be grasped imaginatively. The soul has to dance, so to speak, between observable spaces and familiar laws, on the one hand, and specifically and precisely imagined spaces and phenomena, on the other. We learn to see with the mind’s eye, and even draw what only the mind can actually see. Thus, the mathematical mindset that once estranged us from the non-physical worlds becomes a gateway back into these worlds.

The Empathetic Soul

Encounters that originate with the Empathetic Soul are most easily characterized as those moments when someone else sees us. Beyond gender, race, age, appearance, status, and all the other veils that hide us from one another, we are, all of us, human beings, each one of us a species unto ourselves. When another person can see us, we are neither simply attractive or repulsive, nor are we explained through some pre-existing model (not even an anthroposophic one). While these interpretations will, no doubt, play into what another sees, he or she can see something genuine—us, or something of us. It is an exhilarating moment! It is just as exhilarating when we are the ones who manage to see—really see—another human being. On the few occasions in my life when that has happened, I have felt like Adam in the Garden of Eden.

There is such simplicity and purity in this kind of encounter; it leaves your heart open and receptive, without the veils that customarily come between people. The question then arises: What happens now?

When one person sees another, there are usually only two basic choices to be made: to love or to hurt. I don’t mean sensual love; I mean that you have seen another human being, including his or her golden qualities and less-than-golden needs. To the needs you can respond with whatever it is you have to offer. To the other’s golden qualities you respond by calling them forth. Or you can put a hook into the need and begin to manipulate. You can also ignore, remain indifferent, but that is just another way of hurting. And you can try to undermine the golden qualities.

We have all met people of both kinds of resolve. In the presence of someone who has seen another and chosen love, we feel peace.

With those who lust for power and who utilize their insights for control and manipulation,

Encounters that originate with the Empathetic Soul are most easily characterized as those moments when someone else sees us.

we can feel helpless. They are far too clever and skilled for us to meet head on. We can sense that ultimately only love can counter their power. It cannot redeem them, but it can serve as a countermeasure within individuals and communities. The opportunity for love to build momentum in our situation may take time. In the meantime, they can do a lot of damage.

As I mentioned before, there is no direct remediation of the dark impulses we are talking about. But if love is ultimately the antidote, there are a couple of practices that we can take up in order to strengthen our relationship with the Love Impulse. There are others, too, but we are focusing now on collegial relationships.

1. The first is biography work. This is a fairly well-developed field of study in our circles, with people who are skilled at facilitating excellent processes. Entering attentively into the images of another's life and then taking those into our sleep life for several days can go a long way toward building a real feeling of brotherhood and sisterhood.

2. The second is meditation. The path toward the Love Impulse needs to be taken up within each one of us. As Steiner developed this work, an essential aspect of it is that we first build up a picture, and then we allow what we have achieved to disappear, to die, as it were. Only the force we had built up in the process of forming the image remains. Apart from the value of meditative work as a spiritual path of knowledge, the practice of letting something die within us is a profound step toward Love.

When death is approached without fear, anger, or resentment, it can be the most amazingly graceful moment in the whole of life. We can "gift" our dying to those around us as their opportunity to care. In the realm of ideas, death means renouncing our ownership

and attachment to what originally came to us, allowing it to be owned and revised by the group. And when we see another person, with her physical, emotional, karmic, or any other illness, we can ask ourselves: "Were she on death's bed,

would I love her?" If the answer is yes, and few of us would choose to attack or ignore a person on death's bed, the next question is: "Why should I wait until she is on death's bed to love her?"

We find, when approaching our fellow human being with the mindset that "Love shouldn't wait," that the twin experiences of surprise and invigoration meet us all the time. Just like a good College meeting!

When death is approached without fear, anger, or resentment, it can be the most ... graceful moment in the whole of life.

ENDNOTES

- 1 For a summary of Steiner's threefold image of the human being, see my "Contribution to the Study of the First Core Principle." *Research Bulletin* 19(2): 54–57, 2014.
- 2 Craig Holdrege's work encompasses plant and animal studies, and can be found at www.natureinstitute.org; Dennis Klocek studies a wide range of natural phenomena. His work can be accessed at www.coros.org.

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In this third and final article of a series on digital technology published in the *Research Bulletin*, I intend to explore some of the larger themes, perspectives, and implications connected with the digital gesture. The previous two articles focused on the origins and elements of this gesture—binary, Boolean algebra, data as *the* medium for the digital age—and elaborated on the experiences, ideas, and technologies emerging from the present state of the art, with particular emphasis on various virtual and augmented reality systems, further touching on the incipience of artificial intelligence. Throughout, it has been my aim to trace the trajectory of the digital gesture as an underlying impulse. In what follows, I hope to identify some final landmarks along the path marked out by the digital gesture as it disappears into the horizon of the future.

Simulacra

What is an image? This single question can call to mind a litany of others, many of which touch on historic difficulties in the domains of philosophy and religion that lead far beyond the scope of an exploration into the nature of digital technology. Yet, working with this question and some of the difficulties connected with it can lead to a deeper understanding of the digital gesture, even if the journey is somewhat circuitous.

One simple answer as to what an image *is* could be: anything that represents something else. A photograph of a rose, for instance, *represents* the rose of which it is an image. But what is the difference between the image and what it represents? What makes them the same? Why is this difference or sameness important? Leaving aside, for the time being, almost the entirety of aesthetics, semiotics, and other

pertinent fields of investigation, one could naïvely venture that an understanding of the difference between an image and the *something* that it represents is vital when approaching the question as to what that something *is*. And a feeling for the *difference* between image and object is in turn essential for one's orientation to what could be called *reality*. Without the right orientation, one is in danger of confusing the menu with the meal, or, as in Plato's Cave, the shadow for the object—or being—that casts it.

To study the digital gesture in light of the questions surrounding the nature of an image requires, in the first place, a shift in hue. Since words themselves are images of a sort and have their own origins, orientations, and shades of meaning, a word more apt than “image” is called for, as the latter carries connotations not proper to the digital realm. Happily, the all-embracing genius of the English language readily supplies a word, adopted from the Latin in the 16th century, that illuminates the traces of the digital gesture perfectly, and that word is *simulacrum*.¹

Jean Baudrillard, one of the preeminent postmodern philosophers of the 20th century, wrote extensively about what he saw as a growing tendency toward abstraction living in every aspect of modern civilization. He described a “precession of simulacra” whereby the simulacra begin to function in place of the “real.” He delineated four “successive phases of the image”:

It is the reflection of a profound reality;
it masks and denatures a profound reality;
it masks the *absence* of a profound reality;
it has no relation to any reality whatsoever:
It is its own pure simulacrum.
(Baudrillard 1994, 6)

Baudrillard coined the term *hyperreal* for the last and highest level of simulacra, highest in the sense of being the most abstracted from any origin or reality.² He theorized that as the simulacra precess further and further from the axis delineated by their real counterparts—and appear to become more and more “real” in and of themselves—they increasingly work back on whatever remains of the original world and set it spinning on a new axis: the axis of “pure simulation.”

At the beginning of his book *Simulacra and Simulations*, Baudrillard recalls an image from the Argentinian author, Jorge Luis Borges, of a map that completely covers its territory both in extent and detail. Simply covering the territory (real) with a map (simulacrum) is only the first step, however, toward “true” simulation. Once the map itself begins to be copied, transformed, reflected, distorted, destroyed, et cetera—once the simulacrum increasingly receives the attention and activity of human beings while simultaneously concealing what it is not—all ties to the original territory are in danger of being severed. Baudrillard predicted that eventually all cultural, economic, and individual experience would become mediated by an opaque system of functional code.³ He believed that advertising would be one of the prime mediums for the development of this system.⁴ As an exemplar of a 20th-century simulation driven by advertising, Baudrillard evokes a well-known “mirage” in the desert:

When one sees Las Vegas rise whole from the desert in the radiance of advertising at dusk, and return to the desert when dawn breaks, one sees that advertising is not what brightens or decorates the walls; it is what effaces the walls, effaces the streets, the facades, and all the architecture, effaces any support and any depth, and that it is this liquidation, this reabsorption of everything into the surface (whatever signs circulate there) that plunges us into [a] stupefied, hyperreal euphoria that

we would not exchange for anything else, and that is the empty and inescapable form of seduction. (Baudrillard 1994, 91-92)

Inside the simulation, everything collapses into an empty image of seduction: What happens in Vegas stays in Vegas. How might one counter such a “stupefied, hyperreal euphoria” in the 21st century when the surface of seduction lurks no further than the nearest smartphone?

A Feeling for Difference in the Ways of Revealing

As a university student in the early 1990s, about the same time when I first met the work of Baudrillard, I encountered a computer system that could purportedly create original musical compositions in the style of well-known classical composers. The system’s capabilities were demonstrated through a kind of musical Turing test.⁵ Two music pieces were played in succession through hidden speakers; one of the pieces was the actual work of a human composer, say, Beethoven, and the other a work “composed” by software. Determining which was which was left up to the listener. (Strictly speaking, both pieces were simulacra in that they were both played through the medium of an electronic sound system.) I am somewhat abashed to report that I was unable to discern the “real” from the “simulated” music. But what prevented me from doing so? Perhaps it was a lack of familiarity. If, instead of my limited exposure to Beethoven, I had been previously acquainted with every single instance of the composer’s work, I could have easily deduced which of the two compositions was not among those instances. Such a method, however, in addition to being implausible, would have missed the spirit of such a test. What then?

In my case, upon learning which work was which, even my underdeveloped musical sense could detect a certain repetitiveness in the music that was “composed” by the software, a repetitiveness that I found to be satisfyingly absent from the work once conceived by a living,

breathing human composer. Only in retrospect—and by repeating the test—was I able to distinguish between the real and the simulacrum. This new-found sensitivity took the form of a *feeling for the difference between the two*.

I have since come to associate this and similar experiences with the two-edged sword of digital technology: It can ultimately only reveal what it lacks, and the revelation of what is absent emphasizes that which may otherwise be present. Or, put another way, the experiences built upon the minimal difference implicit to the digital gesture can stimulate the development of a fine sense of discernment between differing qualities of *difference as such*. Like the sudden epiphany that comes when one finally grasps the elusive solution to a seemingly impossible riddle, one of the obscure gifts that the digital gesture can offer to human consciousness is a realization of the very thing that is otherwise effaced by digital technology.

Eight years after the invention of the transistor, the philosophic underpinnings for just such a viewpoint were laid by Martin Heidegger, when he gave an enigmatic lecture on “The Question Concerning Technology.” In a subsequent essay based on this lecture, Heidegger describes the essence of all technology as “a way of revealing” in line with the Greek concept of *poiēsis*, which is the origin of the English word “poetry.” By contrast, he characterizes the “modern” technology of 1955 as a kind of “enframing” that threatens to “conceal *revealing itself*” by reducing the act of revealing to mere ordering. He goes on to say that, if the revealed world were to become “merely ordered,” then humankind would be cut off from any access to truth and beauty. He concludes the essay by claiming that the only way to save humanity from such a fate is to hold the danger of technology “always before our eyes” and to decisively confront it in the realm of art (Heidegger 1977).

Language in a Hall of Mirrors

Heidegger’s contribution to an understanding of the digital gesture is not straightforward or easy to grasp, especially for non-German speakers. Throughout his essay on technology, Heidegger plays with language and the meaning of words in ways that are more akin to poetry than to prose. Heidegger’s “poetic revealing” is apropos of his conviction that art is the necessary countermeasure to the dangers posed by technology. The words of the essay become more than representatives of meaning; they begin to have resonance with each other and with their own origins; they sound forth and are no longer content simply to lie on the page. In a way

reminiscent of Plato’s *Cratylus*, Heidegger strives to let the words, and even the sounds composing the words, begin to speak for themselves. By confronting the question of technology through “that revealing that brings forth truth into the splendor of radiant appearing,” Heidegger opens a way forward. Even in our time

“we can be astounded,” for instance, that, despite the specter of a rapidly multiplying digital opus—overstuffed by millions of Twitter feeds and threatening to swallow every last bit of attention—one can still be open to the question as to whether humankind can successfully “dwell poetically upon this earth.”

In a recent book review for *The New Yorker* that questions the life-changing nature of poetry, Louis Menand writes that “language is a profoundly mysterious technology.” He then reveals that he himself became a writer (and Pulitzer Prize winner) due to his own encounter with poetry as a teenager.⁶ It is just this sort of acknowledged *experience* that stands over and against the digital gesture as a counterweight, even as the “mysterious technology” of language itself comes under threat of being digitized, enframed by an only *apparently* mysterious technology.

I have since come to associate this and similar experiences with the two-edged sword of digital technology: It can ultimately only reveal what it lacks.

After all, it is no small occasion that the office formerly attributed to the leader of the free world is currently occupied by a man who conveys some of his most influential missives through a messaging system limited to 140 characters. Imagine! Once set into order via a tiny virtual keyboard, those few dozen characters are sent through thousands of interconnected digital systems. They then gleam forth from the surface of millions of screens positioned all around the globe, one digital copy for each subscriber, revealing... what? These cryptic messages—simulacra of printed words—are “read” by millions of human beings in turn, mostly through the lens of a pre-established bias of one sort or another, triggering more messages to be loosed back into the system, messages which then gleam forth and are read, and so on, and so on. Throughout this wholly digital realm, there is no revealing, no “bringing forth truth into the splendor of radiant appearing.” There is only the functional operation of the code cycling within the system. The entire cycle bears the mark of *recursion*. The tendency to be recursive, for the code to work back on itself in a feedback loop, is a sign of the digital gesture, the algorithm, the simulation.

The simulation *requires recursion to create distance from the real*. Simulations enabled by the digital gesture ultimately alter the beholder’s belief as to what the simulacrum *is* by enframing an entire ecosystem for it, by creating a context in which the simulacrum can “really” exist. What *is* being communicated through the Presidential Twitter feed? Or, returning to the image: What *is* the image of a rose that appears on my screen? *Is* it an email attachment? Or is it part of a tweet instead? Is it my desktop background? Is it an image *of anything at all*? Or is it an image of all the ones and zeros hidden from view? But aren’t the ones and zeros themselves an image of the “real” rose that has been rendered into digital data? Does the image cease to exist if I delete it? A hall of mirrors. How many layers of context and meaning are needed before these questions can even be approached?

Similar to the saving power of the poetic, turning one’s attention to the natural world can help one to reorient after such dizzying questions. Nature is abundant with layers of context and meaning that work together as an “open secret.” What if, instead of transplanting a rose into the digital realm, we were to take an exact simulacrum of a rose seed—an atomic likeness of the “real thing”—over into the natural realm? Would the exact simulacrum respond poetically in this context? It is difficult to imagine that cold, water, sun, and soil would conspire to make the simulacrum sprout.

Apocalypse as Revealing

Just as definitively answered questions can end the fruitfulness of a good conversation, images or words fixed within a cultural context can dull individual creativity. For the modern reader, the word “apocalypse” most likely conjures a mediated vision of the end of times, replete with images of desperate survival in the face of scorched landscapes, zombies, malicious machines, or all of these at once. The ongoing financial success of the *Matrix* and *Terminator* franchises—both of which are slated to be “rebooted” soon for a new generation—is a testament to the fact that the depiction of a dystopian future wrought by renegade machine intelligence continues to be a trope in popular culture. This version of the future, magnified by an unstable political climate and seemingly relentless technological innovation, can appear to be an inevitability. The individual can seem to have no recourse. Nonetheless, the fact remains: Each small step toward a future enframed by digital technology must be taken by an individual human being. This fact looms less large and has been far less dramatized.

Here again, the genius of language can come to our assistance by offering a more potent meaning for *apocalypse*, a meaning quite unlike the culturally encrusted images of an inevitable disaster. The origins of the word “apocalypse” dwell in some other future vision. In that place—

that of the original Apocalypse—illuminated and resounding, self-knowledge works to *uncover* or *reveal*. Apocalypse is not, in this sense, a vision of an unavoidable future, but rather a mood or imaginative context that can facilitate the exploration of intentions rather than outcomes. Becoming aware of the differences in meaning inhering within the word “apocalypse” can be instructive for evaluating the true impulses behind the images that arise in day-to-day life, especially those that are the result of mediation or bias.

Recall, for example, the historic encounter between the chess grandmaster Garry Kasparov and IBM’s Deep Blue computer. Before the match, Kasparov expounded on how the computer was unable to “understand” chess the way he could and vowed to “be the man who [would] save our pride, human pride.” The lead computer programmer, on the other hand, wanted to create a machine intelligence “in the image of man.” Neither came to pass. Despite heroic claims to an intelligence beyond the capabilities of mere calculation, Kasparov was eventually defeated by a subsequent iteration of Deep Blue. And, despite its obvious efficacy, a chess computer—even one without human peer—can not be a true “image of man.” Furthermore, the fact that a human being lost to a computer at chess does not *mean* that human beings are obsolete, or that a computer has attained human intelligence; these are merely appearances. Both Kasparov and the computer scientist invoked their own *personal images* as justification for their respective intentions. But these personal images do not inhabit a common reality any more than the *Terminator* and *Matrix* movies describe a common apocalypse. The frame of an image, whether it is of “man” or of technology, necessarily sets limits to the very image it enframes. The digital gesture insists that one oscillate ceaselessly between the two. An apocalyptic mood does not insist.

Each small step toward a future enframed by digital technology must be taken by an individual human being.

The Black Box of Machine Learning

In both senses of the word, the apocalypse is now. The machines are “learning” without being “taught.” Just as many children today are regularly exposed to touchscreen technology as a sort of digital babysitter⁷—often justified in the minds of caregivers by the installation of “edutainment” and “infotainment” apps—so too is digital technology increasingly left to its own self-education.

Many of the most advanced digital systems are not “programmed” in the traditional sense. Instead, they are designed as “neural networks” that simulate the kinds of layered connections found—or imagined to be found—in the nervous systems of living organisms. (Whether an artificial

neural network can be regarded as an image *taken from* or *projected onto* an organism is an open question.) And, just as young children need experiences to learn anything at all, an artificial neural

network, or ANN, first needs to be “trained” if it is ever going to successfully perform useful functions, a process sometimes referred to as “deep learning.” Unlike the case of a young child, the training of an ANN does not require much attention from its guardians after it is created. The training *does* require a prodigious amount of digital data to percolate through the layers of the neural network. The data are fed into the visible input layer of the network, progress through hidden processing layers, and then emerge at the visible output layer. As the adjective “hidden” implies, what exactly occurs in the inner processing layers is *not known*. Meaning, literally *no one knows* exactly what is happening at this level of the simulation.

There are many examples of artificial neural networks already “in the wild.” Facebook, for instance, uses a neural network for its translation services. Google uses deep learning techniques to index online images for better search results. Existing resources have proven to be sufficient for

the training regimen of these intelligent digital machines. Soon, however, the data collected from the vast online troves of digitized images, texts, and financial transactions will no longer suffice.

Here, as in many other cases, Baudrillard is uncannily prescient. Writing in 1981 about the now-commonplace technology of cloning, Baudrillard speculated that, in effect, such prowess was the result of “what happens to the body when it ceases to be conceived as anything but a message, as a stockpile of information and of messages, as fodder for data processing” (Baudrillard 1994, 99–100).

In 2017, we need not clone our physical bodies for such a conception to play a role in our everyday experience. Our “algorithmic self” serves this purpose instead.⁸ An individual’s Fitbit data, Amazon Prime viewing habits, and Google search history constitute a digital body that has indeed become “fodder for data processing”; more than fodder: It is a gold mine.

A recent article in *The Guardian* summarizes the present situation well:

Silicon Valley is an extractive industry. Its resource isn’t oil or copper, but data. Companies harvest this data by observing as much of our online activity as they can. ... [C]ompanies can [thereby] discover patterns that help determine what kind of person you are—and what kind of things you might buy.

These patterns are highly profitable. Silicon Valley uses them to sell you products or to sell you to advertisers. But feeding the algorithms that produce these patterns requires a steady stream of data. ... For Silicon Valley... anything less than total knowledge of its users represents lost revenue. Any unmonitored moment is a missed opportunity.

Amazon [who recently acquired Whole Foods Market] is going to show the industry how to monitor more moments: by making

corporate surveillance as deeply embedded in our physical environment as it is in our virtual one. Silicon Valley already earns vast sums of money from watching what we do online. Soon it’ll earn even more money from watching what we do *offline*. (Tarnoff 2017)

Transforming the Digital Crown

Such is the nature of the digital apocalypse; we human beings *are* growing together with the technology of our own creating. But *how* we grow together will continue to depend on individually-induced inflection points. It is still possible to live *without* a smartphone, just as it is possible to live *with* the intention of understanding what a smartphone actually *is*.

The advent of functional machine intelligence is proof that a certain type of enframed thinking can be projected into the external world as an image taken from the tapestry of soul experiences accessible to human consciousness. “Thinking” that has been separated out and isolated by

It is still possible to live *without* a smartphone, just as it is possible to live *with* the intention of understanding what a smartphone actually *is*.

the digital gesture can be easily mistaken for the *activity of thinking itself*, precisely because the former is, relatively speaking, *visible*, manifested to the senses through the medium of digital technology, while the latter—the activity of thinking—remains, at least initially, *unrevealed*. According to Rudolf Steiner, there cannot be “a satisfactory solution to all the riddles of life” without an experience of what lies unrevealed, nor can human beings progress beyond what the intellect alone provides to consciousness. It follows that any form of intellect that can be simulated by a digital machine will also be unable to reveal solutions to the “riddles of life.”

In his work, Steiner repeatedly points to the fact that the first step toward higher cognition always requires clarity of thinking and the capability to follow a thought through to its logical end. He also emphasizes that “never before has there been a time when clear thinking

has been as necessary for human evolution as are eating and drinking for the preservation of the physical body” (Steiner 2006, 109). And, paradoxically, that “illusion is the driving force for [the] development of [our] consciousness” (Steiner 2000, 163).

Whether or not the crescendo of illusion being orchestrated through the digital gesture can be turned to the advantage of human evolution depends on which digital apocalypse comes to pass. In this sense, digital technology is not a tool among tools. It is the state of the art of a certain form of consciousness, the essence of which is based on a minimized difference and the aim of which is to enframe an entire cosmos in terms of that difference. Yet, to echo Heidegger’s words, the “saving power” of art also still holds sway. The digital gesture creates distance, but the poetic gesture draws near to what lies concealed in that distance.

In a lecture on November 25, 1917, Rudolf Steiner stressed the enormous role that machine technology will play in humanity’s future:

The point is not *what* is going to happen, for it certainly will happen, but *how* it happens—how these things are handled. The welding together of human beings with machines will be a great and important problem for the rest of the earth-evolution. (Steiner 1966)

It is my earnest wish that this problem will be taken seriously.

ENDNOTES

- 1 The nouns “simulacrum” (singular) and “simulacra” (plural) stem from the Latin verb *simulare*, meaning “to make like, imitate, copy, represent” (“similar” and “semblance” come from the same root). Between the word “image” and the word “simulacrum” lies a philosophical divide. In *The Sophist*, Plato made the distinction between the work of those artists who respect the proportions of the model and those who do not. The latter, who alter the original proportions of the model in their oversized or inappropriately-colored works, “depart from the truth” and produce “appearance” instead of a true “likeness.” It is this sense of (mere) appearance or of illusion that is captured by the word “simulacrum”; to make a work “similar” to the model is not equal to making a “true” image of it. Ironically, accuracy, an attribute Plato assigns to the true image, seems to be exactly what digital technology has perfected. But this is itself an illusion, as digital calculations can only ever be approximate.
- 2 By definition, “hyperreal” means “beyond real” or “more real than real.” I was once in a small crowd of people during the demonstration of a then-new ultra-high-definition television set. As a video of a popular movie played on the brilliant screen, a child in the group exclaimed: “It looks better than real life!” Years earlier, I myself had a similar experience when I saw a high-resolution computer screen for the first time. I have also heard others describe the change from black-and-white to color television in comparable terms. Each stage of screen innovation may not look “better than real life,” but each stage certainly seems to look “more real” than the last.
- 3 This idea was the basis for *The Matrix*. The directors of the film required the actors to read Baudrillard and their script makes many references to his work. The dramatic arc of the Matrix trilogy begins with the main character developing the capability to discern the real from the simulated and finally ends when he is able to make a free choice within the constraints of both. The first film of the series won four Academy Awards and the Matrix franchise remains one of the most profitable properties in the history of media.
- 4 The idea that advertising could be a medium unto itself is no longer a radical notion. Yet the pure inertia of the advertising behemoth has had an impact on the digital revolution beyond the imaginings of even its most clever architects. As a case in point, the fact that almost 80% of Google’s revenue now comes from advertising is a circumstance never foreseen or intended by either of its two founders. They both had envisioned an entirely different revenue model based on licensing their proprietary search technology. Moreover, they fundamentally eschewed anything pertaining to advertising. This April, however, Google’s parent company, Alphabet, reported first quarter advertising revenue of \$20 billion. That number is expected to increase over the course of the year, an expectation driven, in part, by the fact that artificial intelligence—an actual intention of Google’s founders—has been systematically woven into nearly every aspect of the business, notably its advertising technology.

- 5 In 1950, Alan Turing conceived of the influential test that still bears his name. He intended the test to be a means for determining whether a machine was capable of displaying a level of intelligence equivalent, or at least seemingly equivalent, to that of a human being. During the test, an evaluator having access to only a screen and a keyboard is tasked with having a typed conversation with both the machine being evaluated and another human being. Both the machine and the human control are hidden from view. If by the end of the session the evaluator is not able to reliably identify which of the two is the machine, the machine is considered to have passed the test. Turing emphasized that the point was not to determine whether or not a particular machine could think, but rather to see if it could pass this “imitation game” by seeming to act in the way a human being acts.
- 6 Louis Menand, “Can Poetry Change Your Life?”. *The New Yorker*, July 31, 2017.
- 7 From the journal *Frontiers in Psychology*: “Young children’s access to touch screens has increased rapidly and dramatically. In October 2015, the Pew Research Center reported that at least 83% of all 18- to 49-year-olds in the US—the age group most likely to be parents of young children—owned smartphones. Another recent investigation focusing directly on low-income minority families from suburban Philadelphia with children ranging from 6 months to 4 years painted the same picture: 83% of these families had tablets at home, 77% had smartphones, and 96.6% of the children had used these devices, many before their first birthdays.” (Lovato and Waxman 2016)
- 8 The idea of an “algorithmic self” is a direct progression along the lines that Baudrillard describes. Comparing the industrial age with the information age, he calls the technology of the former “exotechnical,” characterized by the “prosthetic,” and the latter “esotechnical,” represented by “genetic software.” Unlike the more-or-less visible “software” encoded by DNA, the “algorithmic self” is equivalent to a digital double that can never be seen directly (we could call it patatechnical). As online systems increasingly become indispensable for day-to-day life, the care of one’s digital double has already grown to be an existential concern for some people. Frank Pasquale, author of the book *The Black Box Society: The Secret Algorithms That Control Money and Information*, explains: “To negotiate contemporary algorithms of reputation and search—ranging from resumé optimization on LinkedIn to strategic Facebook status updates

to OkCupid [dating] profile grooming—we are increasingly called on to adopt an algorithmic self, one well practiced in strategic self-promotion. This algorithmic selfhood may be critical to finding job opportunities (or even maintaining a reliable circle of friends and family) in an era of accelerating social change.” (Pasquale 2015)

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Technology and the Laws of Thought

Part 3

Gopi Krishna Vijaya

*All stable processes we shall predict.
All unstable processes we shall control.*
— John von Neumann

As the new concepts of digital computing were taking root in the years following World War I, World War II arrived on the scene—and with it a period during which computing technology came into its own. The focus of World War I was on bigger and better guns, while the focus of World War II was on bigger and better bombs. The basic structures of computers known today—memory, stored programs, subroutines, etc.—were developed during the years 1941–1945, and the person at the center of it all was John von Neumann.

Von Neumann had a knack for identifying ideas that could be implemented; working next door to Alan Turing at Princeton, he provided the impetus for the development of the programmable computer. The program and the *software*, as it came to be called, was related to the machine or *hardware*, in this way:

Hardware denotes the electrical circuits that make up a computer. *Software* denotes a list of instructions for the order in which switches open and close. *Computer program* denotes a specific file holding these instructions.
(courtesy plyojump.com)

Prior to his time, computers could mainly be programmed with only one set of instructions. A different program required a physical reconfiguration of the machine. Von Neumann's interest was to transition to a machine that could alter its functioning depending only on the input instructions, a concept very similar

to his collaborator Turing's Universal Machine. Taking an interest in modeling the shock-wave of a bomb, von Neumann focused on the development of high-speed computers for the same purpose. Several electronic computers were being developed simultaneously in this time period, such as the ENIAC, Harvard's Mark I (where Grace Hopper, one of the very first computer *programmers*, worked), Stibitz's Complex Number Calculator, the Selectron, and the Stored Program computer at IAS. Von Neumann was the catalyzing factor between all of them:

Throughout the summer and fall of that year (1944), he shuttled by train between Harvard, Princeton, Bell Labs and Aberdeen, acting as an idea bee, pollinating and cross-pollinating



various teams with the notions that had adhered to his mind as he buzzed around ... von Neumann wandered around gathering elements and concepts that became part of the stored program computer architecture. (Walter Isaacson, *The Innovators*, p. 104)

This fact is quite important as it shows a transition in the nature of creativity, from the brilliant insights of a lone investigator or inventor to collaborative advancement of technology. If the will for the creative development of George Boole's laws of thought came from his religious devotion, the will for the development of computers during this period came from waging wars, which necessarily are a group effort. Hence the transition in creativity is marked clearly:

But the main lesson to draw from the birth of computers is that innovation is usually a group effort, involving collaboration between visionaries and engineers, and that creativity comes from drawing on many sources. Only in storybooks do inventions come like a thunderbolt, or a light bulb popping out of the head of a lone individual in a basement or garret or garage... The sparks come from ideas rubbing against each other rather than as bolts from the blue. (Isaacson, pp. 85, 110)

This is claimed in direct contradiction to the fact that virtually all major developments leading to the computer were done by individuals who received a "bolt from the blue": Leibniz (mathematical logic), Bacon (binary codes), Boole (binary logic), Pascal (mechanical calculator). Here, the fundamental repercussion of the development of mechanical symbolic logic can be identified: *a denial of the very process of creativity*. If the nature of thinking is deemed to be mechanical, and hence finite, the only way to

make progress is to add up more finite chunks. It is hence a direct consequence of rejecting the notion of infinity in human thinking, a point that was highlighted in the previous installment of this essay. The main lesson to draw from this is that if one thinks only mechanically, then innovation is possible only by collaboration.

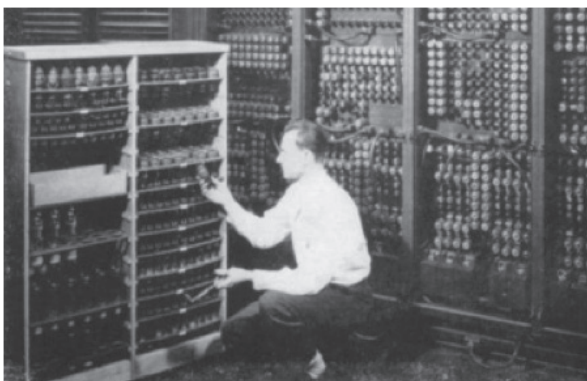
A second consequence of rejecting the infinite in logic is to make up for the same in terms of time and space, i.e., to make computations *faster* (in time) and the computing elements *smaller* (in space). That is the only approach left open for this restricted form of creativity. These two themes, *faster* and *smaller*, reinforced each other and directed all computing innovations every decade since World War II.

Switching had transitioned from the clunky electro-mechanical switches of the 1930s to the silent electronic vacuum tubes of the 1940s (e.g., ENIAC). This increased the speed of operation, even though the tubes failed regularly.

Speed increased every decade from this point onwards. The next shift was accomplished in the 1950s with the invention of the solid

state transistor, which eliminated most problems of vacuum tubes and was also smaller. Speeds increased, and sizes decreased again in the 1960s with the invention of the integrated circuit, which was smaller than a penny and had thousands of

[T]he fundamental repercussion of the development of mechanical symbolic logic can be identified: a denial of the very process of creativity.



Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.



Vacuum tube to transistors to integrated circuits within 25 years (courtesy chipsetc.com)

transistors. By the 1970s an integrated circuit had *millions* of transistors on a microprocessor chip. Nanotechnology, the science of the nanometer range, thus had a large influence on this process.

This high computing capacity enabled the computer to link itself to display technology (television display). Edward Lorenz, who studied weather patterns on such a computer, realized that slight deviations in conditions for solving equations, when reiterated, cause enormous differences. This led to the development of Chaos Theory. Later, Benoit Mandelbrot, who had spent time both at the Institute for Advanced Studies as well as at the computer giant IBM, was able to study iterative systems of equations while studying noises on telephone networks. With computers it became possible to repeat iterations millions of times, which when combined with plotting complex number graphs produced the famous Mandelbrot set and opened the door to the study of fractals. Self-similarity was its key feature. Combining these two qualities—self-similarities and tiny deviations causing huge results—one obtains the properties of *irrational numbers*. These are both self-similar (with infinite series or infinite fractional definitions) and cause large deviations under iteration (1.9999^{20} can become very different from 2^{20}). Until the 1970s, the assumptions made nearly 50 years earlier to neglect irrationals and transcendental

numbers could not have any effect as there was no sufficient number of calculations for those decimal positions to have an effect. But now, it was possible.

Hence these developments, which can be studied only with the help of a computer, resurrected the interest in the beauty of irrational numbers which had lain dormant since the extensive study of *phi*, the Golden Ratio. All the numbers that were neglected when considering symbolic logic and Boolean algebra made a reappearance in the '70s in the study of fractals, but as approximations. Irrationals, complex numbers, and even quaternions made a comeback when computers were used for creating graphics. The very same ideas neglected a century ago resurface as approximations (as they are represented by 0s and 1s) within the digital world. What was eliminated in computing logic by removing the notions such as infinity was now being pursued by increasing iterations and computing speeds relentlessly.

Since the motto of *smaller and faster* has to deal with limitations of technology, the only possibility of enhancing the power of computers was to combine them with existing technologies. This happened in the reverse order, i.e., the latest technology was incorporated first into the computer, then the one before that, and so on. As already described, the most recent technological development before the computers was the cinema and television, which were incorporated by the rise of computer graphics and video games. The next available technology was the earlier development of the telephone. Hence computers were now linked together, like a telephone network. This culminated in the 1990s and determined the rise of the internet. When the internet connection was made wireless, it meant a connection to radio technology and therefore to wireless telegraphy. This determined the rise of Wi-Fi. It is possible to map out the developments in computing which, almost like clockwork, swallowed up the existent technology into themselves to generate a new gadget. The

full development of each type of technology can be represented in waves, like this:

1960s-1970s:	Computer + Television	=	Computer graphics
1970s-1990s:	Computer + Telephone	=	internet
1980s-2000s:	Computer + Radio	=	Wireless internet (Wi-Fi)
	Radio + Telephone	=	Mobile phone
2000s-2010s:	Computer + Radio + Telephone	=	Smartphone

As this trend continues, it is easy to see that the computer will increasingly be linked with all gadgets ever devised by man. Anything that can be operated upon can be automated by a computer: watches, calculators, light switches at home, cars, etc.

Meanwhile, the idea of the brain being similar to computers took a greater hold upon popular imagination, and the idea that computers can “learn” and “think” proved very attractive. Not realizing that no combination of standing or falling dominoes can ever “think,” a type of animism has arisen in computer culture, where, by using human words like “think,” “learn,” “understand” and “figure out,” a sort of consciousness is attributed to the computing process itself. For example, consider this segment of an interview:

Omni Magazine (1987): Do you find it depressing that chess computers are getting so strong?
Claude Shannon: I am not depressed by it. I am rooting for the machines! I have always been on the machines’ side. Ha-ha!

This exchange highlights the anthropomorphic ideas attributed to the computer, which have gained in popularity with every successive decade and every successive rise in computing power. There has been very little focus on the fact that the actual thinking process is a far richer field than that which is described by rote repetition. Even the pioneers in computers who were right in the middle of developing the structure appear to have missed this connection. For example,

Norbert Wiener was a member of Veblen’s circle in World War I who developed the ideas of *cybernetics*: that biological cells and electronic circuits have similar behavior when feedback loops are included. His theory formed the basis for not only computers

but neuroscience as well for a large part of the 20th century. Yet, he made the following statements:

The nervous system and the automatic machine are fundamentally alike in that they are devices, which make decisions on the basis of decisions they made in the past.

Let us remember that the automatic machine is the precise economic equivalent of slave labor. Any labor which competes with slave labor must accept the economic consequences of slave labor.

The logical conclusion from these two statements is that the working nervous system must accept the mental consequences of slave labor! It is interesting to see that Wiener never made this connection and reconsider his ideas on the thinking process, but remained convinced of the identity of the thinking and automatic machines.

However, consider this question from the ideas developed previously with regard to the will-element of human thinking. It is seen that the greatest application of inner effort is necessary for creating a new thought structure, and repetition has a role only so far as the necessary strength has to be developed. In addition, the inner effort applied by our mental process was seen to be a vastly accelerated version of physical bodily exertion. Hence, repetitions and mental calculations have their exact counterpart in gymnastics of the body, where a certain degree of repetition and effort is necessary to develop strength and flexibility.

However, restricting the body to only compulsory repetitive activities tires and wears out the body, as was done with slaves for many centuries. Consequently, all artistic and meaningful movement of the limbs gets neglected. At the same time, the opposite extreme of avoiding the repetitive strength-building activity in the prime of life is also harmful. For example, if a child never learns to walk as it is *always* helped by a walker, or if an adult *always* moves in a machine and never moves his legs, the legs atrophy and decay. Looking between these two extremes, it is possible to identify how to navigate between slavery and atrophy. It is to encourage strength-building activities, even repetitive ones, when the body is growing, in order to generate the strength to last a lifetime. Similarly, repetitive calculations and mental exertions are a necessary part of human education, and it is vital to develop the necessary strength of mind and inner effort before one begins to use any “aids to calculation.” It is also important to realize that further increase in mental effort can only be accomplished when creating new ideas. Hence, all technological aids to physical or mental activity will not have a detrimental effect, only if both the body and mind are engaged in activity which is entirely non-repetitive, fresh, and *creative*. Just as a modern-day person may spend the entire day in a cubicle and yet keep the body fit by exercise, dance or social activity, the strength of the thinking capacity which uses computers and calculators all day long can only prevent atrophy if through focus, concentration, and creativity an independent thinking process is developed.

Unfortunately, it is precisely with regard to the development of will-element in thought, that there has been very little understanding.

By the *belief* that thought is mechanical, inner shackles have been placed on the thought process which tend to direct it more and more toward atrophy. Even if a few people display a lot of ingenuity in making computers work, the net effect of using these machines is detrimental to the general populace as long as the will-element in thought goes unrecognized. This gives rise to several repercussions seen in the thought life of people today: unable to calculate without using a calculator, unable to write without using a word processor, unable to remember without using reminders, alarms and search engines, unable to navigate without using the GPS, a sharp rise in attention disorders, etc. Unless this fact is recognized, like the unused limb, our individual thinking capacity and ability to focus will degenerate. Just as the arm or leg loses strength

This gives rise to several repercussions seen in the thought life of people today: unable to calculate without using a calculator, unable to write without using a word processor, unable to remember without using reminders, alarms and search engines, unable to navigate without using the GPS.

when unused, the thinking process loses its strength as well. Since mental processes occur at a much faster time scale, the deterioration can be very rapid as compared to a physical atrophy.

It is not necessary to subscribe to any particular belief system, especially when dealing with technological matters. The belief of identity of mechanism and thought process, invoked by Boole and his contemporaries in the Industrial Era and virtually

unchallenged until today, has had the powerful effect of crippling the will-element of thought. The Modern Olympic games have the motto: *Higher, faster, and stronger*.

However, modern thinking has retained the first two and eliminated the need for strength; it is left only with higher density of mechanical components (*smaller*) and *faster* speeds of operation as its mode of expression. This cripples thought quite effectively.

It might be argued that development of computers in the past few decades have not hindered creativity, but helped develop it. For example, like the printing press of old, the internet allows every user to express thoughts in as many ways as possible. This, however, does not get to the root of the situation, because creativity by definition cannot be bounded. Creativity creates the rules of the game, alters and shapes them; not obeys them. If creativity were truly included right at the very core of computing technology, then a large variation in the types of computers can be expected. But what is the situation in reality?

According to Bigelow, “Von Neumann had one piece of advice for us: not to originate anything.” This helped put the IAS project in the lead. “One of the reasons our group was successful, and got a big jump on others, was that we set up certain limited objectives, namely that we would not produce any new elementary components,” adds Bigelow. “We would try and use the ones which were available for standard communications purposes. We chose vacuum tubes which were in mass production, and very common types, so that we could hope to get reliable components, and not have to go into component research.” (George Dyson, *Turing’s Cathedral*, p. 143)

The basic architecture of the computer has remained unchanged for six decades since IBM developed the first mainframe computers... it was named after John von Neumann. (Darrel Ince, *The Computer*, p. 117)

The basic functions of modern computers haven’t really changed much since John von Neumann’s “stored program concept” and Alan Turing’s “universal machine” propositions of the 1930s. Although the technology functionality has increased exponentially, the process of binary computation (XOR, NAND,

and so on) remains basically unchanged, as do the fundamental concepts of the architecture. (Russell D. Vines, *Wireless Security Essentials*, p. 4)

It is intriguing to see that in spite of the rapid changes in the world of computers, the basic architecture has remained the same for nearly half a century. In fact, that is the imbalance introduced into technological development, where the basic structure remains unchanged, while the surface structure changes much more rapidly than one could keep up with. Even if some variations in architecture are tried out, they do not challenge the digital basis of computing or the notion of counting neurons. Finally, even if there is some interest in analog computers, or a different architecture (e.g., parallel vs. serial, or quantum architecture), the application of symbolic logic itself is not challenged. These developments are perfectly in line with the structure of the logic, and the notion of creativity and novelty being attached to number (*smaller and faster*), making that the only change possible within the rules of the system.

The connection between development of formal logic and physical exertion has been identified quite well by Shenefelt and White:

In fact, one of the chief aims of logic in its systematic development is to render logical judgments as close to brute reflex as possible. This is why we study forms. Forms leap out at the eye. But once we spot them, the thought required is immediately reduced because we know what to do. We know which rules to apply. To say this isn’t to say that logic makes us unthinking, but only that it saves our thinking for other matters, not for determining the mere cogency of arguments, but for anticipating where the arguments are going or why they exist at all. In this respect, then, logic is like walking. The better at it we get, the less we need to think about it and the farther it takes us—to the contemplation of new vistas. (Shenefelt and White, *If A then B*, p. 232)

However, what new vistas are possible if vision itself is impaired? The authors mention new vistas, but do not identify what those vistas might be, or how they can be accessed. This is the most important topic to be addressed at the end of this analysis: Where to go from here? Are there any alternative paths that could have been taken? How can the strength be brought back into the thought process? These are the questions that will be addressed in the final chapter.

The Road Less Taken

But small is the gate and narrow the road that leads to life, and only a few find it.

— Matthew 7:14



A recap of the full sequence of developments up to this point is now in order. In the first place, thinking was seen to have an aspect of pure thinking (such as logic), an aspect of skill (feeling) and an aspect of willing, involving internal effort. The inner effort involved in repetitive mental tasks could be done mechanically as well, which led to interest in calculating machines. In the second place, the idea that thinking and logic could also be mechanical processes started gaining ground, leading to the works of Boole and his contemporaries. The difference between the logic of the Greeks, which had its roots in geometry and arithmetic, and the logic of Boole, which had its root in algebra, was identified. It was also mentioned that a re-evaluation of Euclidean geometry which was happening at the time, made all mathematicians and geometers question their assumptions. The path taken by some of them was to abandon assumptions and axioms based on real life experience (as

was the case with Euclidean) and to construct an entire consistent system of abstract axioms. They reasoned that, since “common sense” had turned out to be misleading to justify the axioms of geometry, the best course was to abandon the common-sense axioms and to allow abstract axioms to form the basis, and shift the focus to the mathematical consistency of this abstract system. As a result, logic was restricted by mathematics.

In this process, a different “common sense” could have been identified, that of the eye. While it is true that parallel lines never touch one another as far as the sense of touch goes, they *do* meet as far as the visual sense is concerned. Two railway lines do meet, according to the eye. However, as already pointed out, an understanding of the visual process and the mathematics associated with it (laws of perspective and projective geometry) was a newcomer on the scene, as opposed to Euclidean geometry and solid laws of construction and geometry. This led to an abandonment of this line of thought, and logic was instead guarded from the intrusion of non-Euclidean or non-algebraic ideas.

Abandonment of non-mathematical ideas, as well as “infinity” within mathematical ideas, enabled the development of logic that could be mechanized. And finally, it was shown that mechanization using only digital changes also restricted the mathematical scope to the integers instead of the continuous geometric line. This had an effect, which was even predicted:

Banish the infinite process, and mathematics pure and applied is reduced to the state in which it was known to the pre-Pythagoreans. (Tobias Dantzig, *Number: The Language of Science*, p. 139)

This has been found to be an exact prediction, as the digital design of the computer has more in common with an elaborate and intricate abacus than any other prior machine. The effect

of this development on the thinking faculty was described in the preceding pages, and it was found that the restriction of the logic, as well as neglect of the element of inner effort (willing) have led to a decline in thinking capacity.

If a different alternative is to be found, the threads of thought must be traced backwards to find the fork in the road. Backtracking to this point in the 1850s when *The Laws of Thought* was first published, a different path can be identified: non-Euclidean geometry. This subject was born during the time of Renaissance with the introduction of perspective in painting, and treated mathematically for the first time by Girard Desargues and Blaise Pascal (contemporaries of Descartes and Leibniz in the 17th century). Carl Friedrich Gauss, who coined the term “non-Euclidean,” actually downplayed the effect of this geometry, as it contradicted Immanuel Kant’s dictum in *Critique of Pure Reason* that Euclidean geometry was the only valid path. Nevertheless, talented mathematicians like Gauss, Janos Bolyai, Nikolai Lobachevsky, and Jakob Steiner investigated the new geometry and helped non-Euclidean geometry come to the foreground in the beginning of the 19th century.

What is the essence of these investigations? It was Euclid’s postulate that parallel lines never meet. However, in non-Euclidean geometry, parallel lines were said to meet: at *infinity*. While at first glance this might seem as absurd as saying that one can calculate something provided infinite time is allowed, non-Euclidean geometry went one more step ahead. With a series of transformations, it was possible to map this point at infinity onto any other point, thus making it have as solid a foundation as Euclidean geometry. Hence, non-Euclidean geometry was the first attempt, since the time of Euclid, to grapple with infinity and treat it mathematically.

Around the same time, what non-Euclidean geometry did to geometry, imaginary numbers did to arithmetic. Introduction of complex numbers, such as “i” (and later “j” and “k” by William Hamilton, in “quaternions”) proved

extremely confusing for mathematical thinking, as one could no longer attribute qualities of “greater than” or “lesser than” to imaginary numbers. It was one thing to deal with irrational and transcendental numbers, which could still be identified on a number line, and quite another to deal with $i=\sqrt{-1}$. Arithmetic and Algebra were completely altered. This is, then, the transformation that occurred in the middle of the 19th century:

Geometry $\Rightarrow$ Non-Euclidean geometry
Arithmetic $\Rightarrow$ Imaginary (complex) numbers

Both these transitions met with violent opposition at the time. Non-Euclidean geometry was involved in “Textbook Wars” (whether or not Euclidean geometry was fundamental), while Hamilton’s introduction of multiple complex numbers was embroiled in the “Quaternion Controversy” (whether or not complex numbers were practical). However, if that thicket is crossed somehow, a new question opens up. Since Greek Logic was founded on geometry and arithmetic, the natural question to ask is: “What happens to logic now?” As identified earlier:

Quantifiers: Arithmetic (All, some, none)
Copulas: Geometry (is, is not)

Reversing this for the 19th century:
Complex Arithmetic: New Quantifiers?
Non-Euclidean Geometry: New Copulas?

This is the fork in the road that has not been well recognized conceptually, even though there was a lot of controversy surrounding these ideas. The road taken has been the one that abandons both these developments, and introduces more axioms into the logical structure, while limiting the existing copulas to just one. However, what if that is not done, and the other path is pursued?

Naturally, one will have to consider that other verbs can serve in place of “is” and “is not.” This means that the law of contradiction can be overcome, therefore, it is not something

absolute for all things in the world. While this statement, that contradiction is possible in the newer avenues for logic, may seem heretical to mathematicians and philosophers today, it is nevertheless the natural next step in the development of logic. The consequences of this are elaborated in a little-known essay by Carl Unger: *The Philosophy of Contradiction* (written in the 1920s). In this he systematically considers what is obtained by overcoming this contradiction, i.e., it gives rise to *logic of becoming* instead of logic of *being*, thus generating a new copula “becomes”:

A is not (not A) => A *becomes* not A

As described further in the essay:

The concept “seed” involves what is other than it is—that is, it should form roots and a stalk; equally is it part of the concept “stalk,” that it should issue in leaves and a blossom. The contradiction in a concept, including what is other than it, is justified when we figure the time relationship as an essential part of the concept. The true concept of a seed is not that it should be equal to itself... The emergence of a contradiction is not, in itself, evidence of a false enquiry. (Carl Unger, *The Philosophy of Contradiction*)

If A is a finite set, not-A is necessarily everything else, i.e., infinite. Hence, this “logic of becoming” *includes* infinity in the same way that projective geometry includes the points at infinity.

This insight is a completely different approach, as it actually modifies the way in which thought is structured, giving a new fruitful basis for logic. As seen with the example of the seed, this opens the door for thinking with concepts which are not repetitive like calculations, and hence require a fresh infusion of inner effort in order to sustain them. This can be contrasted with the current attempts at creating “living automata” under the assumption that with enough complexity, networks, rapid calculations

and feedback loops, life would spontaneously manifest. Unless the very form of thinking is altered, there is no way to get out of this dead-end path and understand living phenomena.

Unger continues this analysis further, which need not be elaborated at this point (but is definitely worth studying), except to emphasize that this understanding passed by virtually unnoticed by the logicians of the period. All the attention was focused on making the fortress of axioms impregnable. Even the eventual discovery of paradoxes by Gödel and Turing, coming as it did in the middle of World Wars, did not deter the use of this logic but rather made it more rigid.

Taking a different turn opens-up worlds of possibilities. To get an idea of it, consider all the verbs that could have taken the place of “is/is not”! All of these form possible alternatives to the copula in logic, enabling a real extension of it. It also provides the vital clue to solving the problem posed in the beginning of this work: Does a machine affect the way one thinks, and if so, how to tackle the problem? This can now be addressed properly. Thinking has an aspect that has to do with inner effort, and this grows strong with novelty and originality. Rote repetition alone does not allow this, and can hence be safely outsourced to the machine. Thinking using symbolic logic alone requires some effort, but it does not allow one to change the rules of the game, crippling its limits. Thus, the only option is to proceed to strengthen thinking by contemplation of new forms of logic, so that one can treat every event as a fresh situation instead of trying to force-fit situations into a mechanizable model.

It also provides a guideline for providing access to technology while learning. Just as a toddler is not given outer support at the moment it is learning to walk, but instead is provided with encouragement to walk on its own, no technological aids to calculation must be used until one knows how to calculate on one’s own. Just as no harm is done when a physically fit person uses a motorbike, it is safe

to use calculators, for example, only when one can conveniently calculate in one's own mind. There can be individual variations in the process, but the principle holds. If technological aids are introduced before the corresponding strength is built up in the thought process, it would act as a permanent crippling factor, and be very hard to overcome in later life. While particular care is to be taken with all aids to the thinking process while a young adult is growing up, a similar principle holds for adult life as well. For example, if memory is not cultivated inwardly by taking an interest in events and retaining them in the mind due to the force of will, all aids to memory would have a crippling effect on individual memory. If there is a tendency to simply search for answers to questions, then it would become apparent that not only memory, but logic suffers as well, and it would become more and more difficult to actually engage in thinking, and easier to simply play by the rules. Additionally, if it is not clear that true creativity and originality involves thinking that is not mechanical or repetitive, then it is possible for thought itself to become automatic, making man more machine-like in nature.

Thus, following this path from the fork offers a way to not only come to terms with logic and thinking in general, but provides the knowledge based on which safeguards can be identified for the use of computing technology. It is also possible for the Craftsman to embark on technology of a different sort than the ones generally used, and to consider entirely different architectures for machines. So far, the early pioneers in computer technology had obtained their motivation either from religious impulses, or from greed and war impulses. The identification that inner effort can be cultivated independently, and that it can be strengthened along specific

ways, offers a new route: the impulse born of the desire to help, which is a human trait worthy of cultivation. The path which had been blocked so far, due to the rigid nature of the assumptions that the Philosophers had inculcated into technology, can be cleared for Craftsmen having this motivation behind their work.

Strengthening the thinking process also provides a balance between thinking and willing, so that skill and art from the realm of *feeling* can once more enter into the thought process. Individual and cultural differences can enter once more both into technology and ideas, rather than one uniform pattern being applied over the entire world (an inevitable consequence of adherence to mechanical logic alone). This would allow individuals to build on the successes of their predecessors, by remembering, understanding, and carrying forward the impulses of the older cultures in a new form. It is time that novelty no longer means simply a smaller, faster, or more powerful re-packaged version of the old, but is genuinely new. It is only then that instead of facing a future shock, one can look the future in the eye, go forward and *create* it.

Just as a toddler is not given outer support at the moment it is learning to walk, but instead is provided with encouragement to walk on its own, no technological aids to calculation must be used until one knows how to calculate on one's own.

Conclusion

It has been shown that the central theme underlying the analysis of computing and thought is the notion that thought contains an element beyond logic alone in the internal effort or will. This opened the door to identify that the developments in logic and computations of the past century have focused entirely on the logic itself, rather than seeking the origins of it or elements beyond it. It has also been shown that the major transformation that occurred at the end of the 19th century served to restrict logic to that which can be mechanized; a decision that has had massive repercussions in the way one

understands thinking, and consequently, the way one views the human being.

A look at the origins of logic showed its dependence on physical experience and mathematics, as elaborated for nearly two thousand years since the Greek era. When the basic tenets of Euclidean geometry came to be questioned, it was time to revamp logic as well as to remain true to this way of organizing thought. However, the opposite course of action, that of restricting logic even further to only that which can be mechanized, was carried out, leading to the phenomenal importance given to computing in today's world, over and above that given to new ways of thinking. This caused a sort of re-inventing the wheel, where all the paradoxes of the Greek logic came back to haunt developments in symbolic logic and computation as well.

Once it is *assumed* that thinking is identical to a mechanism, it leads to several repercussions, the first of which was already mentioned as a marked decrease in mental will power, and a resultant drop in memory, attention spans, focusing ability and creativity. However, this is not the only effect of mechanical logic over-reaching its boundaries. Human nature becomes increasingly rigid, as phrases like "I can't help it, this is the way I am wired" or "It is in his DNA" become prevalent. This undercurrent of belief, that a human is as programmable as a computer, changes the personalities of people, making them increasingly resistant to new ideas at a rate

greater than ever before. At no point in history has mankind's thought been linked with machines to the extent that it occurs today, and there is a very real danger of jettisoning the very essence of thought from everyday behavior.

When symbolic logic, which is at home in the domain of logistics, penetrates thoughts relating to human relationships, it would have the natural effect of determining if people fit together like cogs in a machine or not. Relationships are retained only as long as the gears and hooks connect, and abandoned and replaced when they are not. This is the only type of thinking possible with this logic, and naturally, as relationships do not fit the box of symbolic logic, either the logic has to be abandoned or the relationship. Thus, misplaced application of this form of thinking can lead to significant tearing of relationships, and devaluing of human worth.

However, when it is accepted that this form of machine-logic is a small subset of the full range of capacities of the thought process, then it would be possible to prevent harm and actually use it for relieving the mind of rote repetitive work. In addition, the independent development of internal effort of thinking can take up its rightful role in preventing the atrophy of thinking and invigorating it in new artistic and creative directions, rather than making a smaller and faster version of the old. The Philosopher can once more shake hands with the Craftsman, as well as with the Artist that brings the two together.

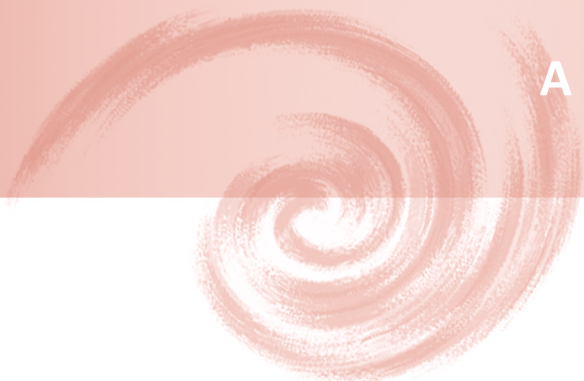


Metropolis (1927)

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A Computer Science Curriculum for Waldorf Schools

Harlan Gilbert and Jennifer Mankoff

In today's world, children encounter an unimaginable wealth of technological opportunity. While there are ample opportunities to passively consume the products of technology, as educators we want our students to stand in the world as active creators, able to direct technology rather than being ruled by it and to use technology's power to create changes that matter in the world.

The following is an attempt to describe an age-appropriate sequence of activities, skills, and knowledge that the authors have been exploring with grade school students in Waldorf settings. We begin by describing the principal themes that we believe are appropriate and important to cover in the upper elementary school. We then present feasible topics organized by grade. The curriculum we are advocating is intended to deconstruct what appears as magical technology into its constituent parts and to help children achieve the freedom and power to use these creatively to construct new things. Our goal in this article is to outline best practices for introducing technological concepts to and cultivating abilities in upper elementary school students, grounded in our experiences over the last five years.

Major Topic Areas

Upper grade school students are very interested in learning about the technological phenomena of our age: music players, computers, the internet, etc. As these technologies are being adopted at home, at school, and in society generally, it is critical to demystify computers. However, much of modern technology is too abstract to be fully understood

in the experiential form that supports creative inquiry and production in the upper grades elementary school years. Students should leave elementary school with a solid understanding of technology, including the languages used to communicate through technology, the importance of precision, and the long life of information posted online. Students should develop an understanding of the limitations and unforgiving nature of technology as well as its power for good. We focus on four main topic areas:

Communication: The wish to communicate is one of the most basic drives that define humanity, and many of our inventions and technologies have been concerned with communication, from the earliest spoken and written language through the printing press, telephone, internet, email, texting, and social networks. Students benefit from learning about the relationship of technology to communication, as well as the limitations inherent in this relationship. This requires exploring the acts of representing and conveying information, the potential for and correction of errors, the issues of privacy and encryption, and so on.

It is extremely important for upper elementary school students today to become more conscious of their communication and its consequences, both in person and on social media. Schools—including, in our own experience, Waldorf schools—are confronted with problematic online behavior, such as the viewing of pornography, the posting of ill-advised emails or social media as early as fifth grade, and excessive game-playing and

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binge watching as early as seventh grade. Preparing students for technologically mediated communication has become a task of our times. The permanency of content and lack of privacy, the social consequences of online behavior, and the appropriateness (and hurtfulness) of personal communications should continue to be addressed. The existence of incorrect, inappropriate, and potentially even illegal online information should be faced—students will most likely be encountering it at home and sharing it with one another.¹

Physical sciences:

Electromagnetic circuitry underpins much of today's technology. The physical underpinnings of the interface between technological devices and the world (namely, the flow of input, or sensing, and output, or actuation) are at the focus of study as the curriculum moves into explaining how technology works. This begins by exploring the simplest possible signals (such as a switch or an LED light). Depending on the time available, lessons can broaden the scope to include more complex inputs (such as keyboard, mouse, microphone, or camera) and outputs (such as mechanical actuation). Students at this age are excited to learn how the devices so pervasive in modern life actually function. By moving these devices from the realm of semi-magical influences to the realm of practical understanding, we help to shift the balance of power from device to student.

Logic: During their upper elementary school years, students awaken to their powers of logical thinking. It is important to teach students how to think through questions logically and to articulate the steps of a process carefully. This is the essence of programming, employing a logical procedure to empower students to create something useful, new, fun and relevant. After learning to make visual depictions of the flow of

decision-making, students can begin to translate these flow charts into the language of computers. Conversely, learning to analyze a problem and find a structured solution path can also provide insights into broader areas of problem-solving.

Crafts: The ability to find practical solutions to real-world problems can be extended by acquiring technical facility with new tools. In the context of technology, computational crafting opens students to the possibility that technology can be part of something beautiful, functional, and material, and that automation can support the creation of beauty and artifacts of practical use in the world. Solving such “functional design problems helps learners develop intricate inquiry skills that include an iterative feedback loop of observation, hypothesis generation, hypothesis testing, and evaluation of solutions.”²

Practical Skills

By the end of elementary school, students should have learned to type and to make use of vetted online databases for reports.

Research skills: In the upper elementary school, it is important to introduce research skills in a supervised fashion. The challenge here is to first build an understanding of reliable sources, authorship, and fair use in printed works, and then to expand this understanding to online materials, particularly the ability to recognize reliable information online.

Typing: By gaining skill in touch typing before using a keyboard on a regular basis, good habits will be established. Given the prevalence of keyboard use today, many grades schools will need to include typing at some point in the curriculum.

Students should leave elementary school with a solid understanding of technology, including the languages used to communicate, through technology, the importance of precision, and the long life of information posted online.

Computing at Home and at School

By seventh or eighth grade, computers are occasionally used for homework in some schools, and students in group projects may coordinate the use of computers/social media. It is therefore important to formulate clear rules and foster informed choices about the appropriateness of device use at school and at home for school work.

Students and teachers can together reflect on how easily devices affect the quality of time spent on a task and how easily the use of these devices can become addictive. It can be helpful to view a movie treating themes such as screen hygiene and risks, bullying, inappropriate content (such as pornography), and online safety, then follow up the screening with discussions of these themes.³ These topics can also be addressed when studying health and physiology: There is, after all, a physiological component to addiction and a neurological basis for mental distraction.

Teachers and parents may also want to explore these issues together. Older parents who did not grow up with these technologies, may not have the same degree of personal experience as do teachers, who have watched the use of technology accelerate over years and across several generations of children by now. Given the speed at which technology changes, the experiences parents had a generation ago will not be the same as those of their children today.

A Suggested Lesson Plan

It can be challenging to find appropriate ways and times in school to introduce technological concepts. We offer here one set of suggestions based on our experience, our recognition of what children are exposed to today, our understanding of child development, as well as published research on children and technological readiness.⁴ Whether a Waldorf school has a high school or not may also influence when some of these concepts are introduced; for example, schools that end in eighth grade may find themselves introducing certain topics earlier, so that their students are prepared for

the expectations of the high schools they will attend. We look forward to further refining and expanding this curriculum.

FIFTH GRADE

At this age, students are not yet ready for an advanced exploration of technological themes, but they are certainly encountering computers in various forms (and at the very least seeing adults use them). Thus, it is important to begin the process of demystifying the world of computing.

The ideas below can all be addressed in one to three lessons. If only one can be addressed, we would suggest the communication topics.

Logic: The notion of an algorithm can be previewed by having students write out a sequence of practical instructions, e.g., cooking recipes.

Craft: The usual fifth grade handwork project, knitting a sock, directly connects measurement with creativity in a very concrete way. If students measure the foot of the person for whom the sock is intended, knit a swatch, and then use this to calculate the number of stitches per row required, they experience the practical use of logical reasoning and the relation between specification (and specification errors) and outcomes that will ultimately reside at the core of understanding technology.

Communication: At this age, students enjoy making “secret languages.” In this context, the number systems of e.g., Babylonia, Egypt, and China can be introduced as the “secret number systems” of these cultures, while binary numbers can be introduced as the “secret language” of computers. Listening to a fax machine is one way to make this experience concrete.

Alternating between these different ways of representing numbers helps students understand the challenges faced by any communication between cultures, including the challenges encountered by a person instructing a computer to act. This also raises the potential for misunderstanding (error) when encoding and decoding. A concrete example of encoding is the

way checksums of ISBN numbers on books are calculated and used to prevent errors.

Due to the likely use of smart phones, digital readers, and other internet-enabled devices by students of this age, now is also the time to begin raising awareness among parents and students about some of the risks and serious potential problems that students may face when going online.

SIXTH GRADE

Sixth graders are ready for a higher level of abstraction and are better able to generalize relationships. Concepts relating to engineering and logic can reflect this readiness and prepare the groundwork for computational concepts in later years.

As with fifth grade, each of the topics below fits into one to three lessons and is ideally presented in connection with the existing curriculum. Among the topics below, logic and communication should get priority.

Physical sciences: The science and technology of ancient cultures are simple enough that sixth graders can readily understand them. Key examples: Heron's primitive steam engine, Archimedes' host of intriguing machines for defensive warfare and efficient spiral water pump, and Roman central heating, road construction, and water-transport technology (gravity-fed piping, aqueducts).

The physical science curriculum of this grade provides an essential basis for work in later grades with electrical circuits and computing. In the geology block, students should experience magnetic rocks (magnetite) and explore basic phenomena of magnetism. Students can experience how to induce static electricity using amber, as discovered by Thales (*elektron* is Greek for "amber"), and other materials. The study of warmth can include a demonstration of bimetallic strips curling in response to temperature variation and their use in thermostats.⁵

Communication: The phenomenology of perception, a central theme of the year, includes

the way we synthesize successive images into a smooth flow (for a project, see "Craft" below). It is a small leap from perception to representation. Curating a grades school bulletin board provides an opportunity to explore communication in practice and to begin reflecting on what should and can be shared publicly, and how to use different media to do so.

Since online activity is likely to be increasing among the students at this age, this is the time to begin talking about issues such as the spread and permanency of online content and the ease with which online communications may offend. (see endnote 1: *The Cybercivics Curriculum*)

Craft: It can be valuable if the craft curriculum takes up the central study of this year's physics block: investigations into perception. This can happen either in craft lessons or in the form of a science fair. Animations can be created using flipbooks, by making a stroboscopic disk/zoetrope, or stop-motion photography using movable figures out of clay or Legos in front of drawn or painted backgrounds. Students are delighted to discover that the same principles employed in these activities are used in film and video.

The creation and assembly of a physical object also allows students to learn about design, the importance of precision, working in teams, breaking something up into steps, and the importance of checking and rechecking measurements.⁶

Logic: Sixth graders, like the Romans, are very interested in efficiency! Determining how to approach tasks efficiently can be both fun and practical. Examples include the most efficient way to find an entry in an alphabetized reference work (which can lead to the idea of a binary search) or to sort a group of items (for example people by height or first name).⁷ In math instruction, formulas can be presented as ways of making efficient calculations.

SEVENTH GRADE

Seventh graders today are beginning to have an awareness of the social influences of computation, just as their social lives are changing dramatically. In addition, it is likely that they have already or will soon begin to make regular use of online communication. Finally, seventh graders are ready for task-based, step-by-step logical and causal thinking.

The seventh grade curriculum is more expansive in its scope than the lessons of the earlier grades. Though some of the themes can be treated as add-ons to existing topics, a semester-long class on technology is ideal at this stage. We suggest priority be given to working with circuits (the underlying basis of computers), either Scratch programming or a Rube Goldberg machine (both of which offer the experience of translating an algorithm or process into a realized project), and treating the social consequences of online communication.

Physical sciences: In the mechanics main lesson, students should not only learn how simple machines revolutionized medieval technology, but also how the water wheel and windmill offered vastly greater power to drive these technologies. An upper elementary school science fair gives space for autonomous exploration within a structured curriculum, providing a healthy acknowledgment of students' increasing capacities for thoughtful experimentation. The electricity and magnetism curriculum should lead to simple, parallel, and serial circuits using switches and bulbs or LEDs. This can be expanded, if time is available, to include mechanical actuation, e.g., of motors. The concepts of input from the world (sensing) and output to the world (actuation) follow naturally.

Logic: After drawing constructions (e.g., using the Golden Section and Fibonacci sequences), students can attempt to precisely describe the process they employed. This gives an experiential basis to what will later become algorithms using repetition (loops) and decision-making (conditionals).⁸

There are ways of programming computers that do not require technical expertise and are thus accessible to this age group. It is possible to introduce at this age a block-based graphical language such as Scratch (see the eighth grade curriculum below for a fuller explanation of this system).

One way to explore the difficulties and potential of designing a simple user interface is to ask students to design an interactive electronic invitation to the school's May Fair. Students learn how to transform a design concept into something they can express in Scratch. They then test it with their peers and observe the inevitable gulf between their concept and what they can express in the program itself and the experience of someone using the program. After this feedback is incorporated into an improved design in an iterative process, the invitation can be shared with the school community. With such a project, students learn much about the inherent difficulties of making something real with technology and the necessity of being aware of the end-user experience.

Craft: Sewn circuit crafts provide an opportunity to begin experimenting with representing, capturing, and displaying information; possible projects include creating a bookmark that also functions as a book light, a bike glove that can signal a turn, or a sparkling bracelet.⁹ Rube Goldberg machines¹⁰ that incorporate simple machines or circuits provide an exciting way for students to apply these concepts.

Communication: During the Wish, Wonder, and Surprise block, students can be asked: Which gives us more new information—something surprising or something unsurprising? The potential for error (and error correction) during communication is also relevant, as is the wish for privacy and therefore encryption. These ideas set the stage for regarding computers as creative tools shaped by people, demystifying technology, and illustrating the large gap between human methods of communication and what computers can understand.

At this age, when the peer group begins to take paramount importance in a child's life, it is time to discuss how to communicate in a socially appropriate manner, including a description of the bully-victim-bystander triad, and how communication via social media can magnify many social problems. This tender subject needs to be addressed at two levels: first, to raise awareness of each individual's role in social interactions; second, to raise awareness of how much more serious, more permanent, and more widely disseminated hurtful comments can be when made over social media. As students spend increasing time online, the topic of balancing screen time and non-screen time becomes relevant.

The content of the classroom bulletin board might be expanded in seventh grade to include essays and poetry reflecting the internal world of the children or news reports about the school and its community. Students are also ready to understand that language, number, image, and even musical notation are all abstract representations of information, and they are also open to exploring how difficult it is to ensure that interpersonal communications accurately reflect their personal experiences.

Related biographies: Inspiring biographies at this age include those of Leonardo da Vinci, who developed a mechanical lion that walked across a stage, and Blaise Pascal, who developed one of the first calculators to help his aging father, a tax collector, with his accounting. The story of Martin Luther and his use of media provides a relevant illustration of the way information was disseminated in the early modern age.¹¹ This is also a time to consider how different kinds of communication technologies can help address perceptually grounded disabilities. Case studies, such as the very positive impact of pagers on the deaf community, may be appropriate here.

[W]hen the peer group begins to take paramount importance in a child's life, it is time to discuss how to communicate in a socially appropriate manner...and how communication via social media can magnify many social problems.

EIGHTH GRADE

Eighth graders are interested in modern developments, many of which postdate the formation of the Waldorf curriculum. The study of Revolutions should extend beyond the Industrial Revolution to include more recent

technical innovations—power sources, computers, robotics, the internet, mobile devices—and their impacts on society, manufacturing, and the environment.

We envision a modern technology curriculum that provides a historical and experiential view of these concepts. Chief areas include: more efficient tools (steel plow, treadle spinning wheel, flying shuttle loom), new

power sources (water, wind, steam, electricity, and batteries), and automated control systems (computers, robots, computer-controlled manufacturing technologies such as 3D printers, and laser cutters), new communication technologies (telegraph, telephone, radio, movies, the internet, mobile devices, and social media).

The eighth grade curriculum should bring students up-to-date on technological and social developments. Ideally, an entire main lesson course is devoted to technology. Priorities include binary numbers, practical skills, programming, communication, and the technical and social consequences of the Information Revolution.

Computing: Students at this age are interested in the internal workings of computers. Basic concepts to cover include:

Binary Numbers: Computers work in binary, and the relationship of binary numbers to encoding information provides an understanding of the internal operation of computers.

Physical Components: Computers have hardware for memory, computing, and so on. Students can begin to explore what is happening

in a computer by assembling a calculator, PC, or other computational device from components. (There are many kits available.)

Algorithms: Many programs are based on solutions to classic algorithmic problems. Algorithms such as search, sort, path finding, or distributed networking can be understood by acting them out in the classroom.¹²

Input, Output, and Feedback: Positive and negative feedback are fundamental to automation (and are also very prevalent in nature and ecology). Positive feedback loops, which tend to be dangerous, are exemplified by what happens to the noise level at a big party when each person speaks louder, forcing others to also speak louder. The interrelationship of carbon dioxide and global warming is a contemporary example. Negative feedback loops, in contrast, tend to be helpful: They keep our bodies and houses at a stable temperature. James Watts' steam engine governor, which kept the speed of the engine constant, was an ingenious use of negative feedback in the early Industrial Revolution, while electromechanical thermostats (the little round ones that used to be ubiquitous) use mercury switches and bimetallic strips to keep the temperature of a house in a constant range.

Programming: Students can learn to write their own computer programs. There are three main approaches to introducing programming:

- Plug-and-play graphical programming languages such as Scratch,¹³ which invite the student to quickly create an interactive result. If this was already introduced in seventh grade, in eighth grade students could build on this experience by incorporating input from a camera or keyboard and thus explore feedback loops. Students may also design more complex algorithms.
- A simple, easily-learned coding language such as Python, offering the possibility of a programming curriculum that continues into

high school. This is the most general-purpose approach, but also requires patience, accuracy in formulating (and typing!) expressions, and teacher experience.

- Microprocessors, such as the Raspberry Pi, that offer a direct experience of computer hardware (buttons and lights; see the craft project described below) on a manageable scale. This gives the students the most direct experience of the steps by which a computer actually operates and of feedback loops employing a wide variety of sensors; it also requires a teacher who has some experience with the Unix operating system and with electrical circuit design. Great teacher resources¹⁴ are readily available.

Combining craft with logic: By combining programming with building, students can give a computer an ability to sense (input) and act (output). Inputs can be expanded to include a keyboard, mouse, microphone, or camera, and output can be expanded to include lights, motors, etc. Possible projects include: translating text to Morse code using sound or blinking lights and creating an adaptive circuit, such as a light that brightens as the surroundings darken, as a book light might. A fan-powered car might combine a

3D-printed fan model, engineering, and circuitry (and would also require feedback loops, if the students wished to program it to go a certain distance when signaled with a button press).

Precision in measurement, an age-appropriate goal, is critical for technology. For example, 3D-printers, which extend the printing press' capacity for replication to three-dimensional objects, depend upon precise measurement. This is still a very experimental technology that can be difficult to maintain, but there are many examples of students making use of them when in-house expertise is available. One of the most compelling applications is the creation of prosthetic hands for children with

By combining programming with building, students can give a computer an ability to sense (input) and act (output).

limb differences. This presents an opportunity to combine craft, mechanics, and physiology, as well as social engagement.¹⁵

Communication: The printing press could be considered the opening salvo in the Information Revolution. Undertaking interviews and publishing a school newsletter can help students understand print media — journalism, in particular. Many revealing insights can be found by comparing the experiences of writing in a private journal, posting on a public bulletin board, publishing an article (e.g., in a newsletter), and posting on electronic media.

The social and hygienic issues arising from students' expanding activities online should be addressed this year, as well. In addition, online behavior should be addressed in the school's sexual education curriculum.

The telegraph, radio, television, and internet (including email and social media) are progressive discoveries of how electricity can transmit information and how each has wrought important and transformative (even revolutionary!) effects on society. The history of the internet and email is fascinating: This began through collaborations between scientific and university centers and the need of the US Defense Department for a distributed communication system to be resilient against attacks. It was never expected to expand to its present scale.

Practical skills: Students can begin to search online sources, perhaps within quality databases suitable for the specific subject, and determine their trustworthiness. Public librarians can be an excellent resource for this kind of research. If students are using email, it is critical that they are introduced to concepts such as phishing, scamming, and spam, and that they are taught how to recognize and avoid them.¹⁶

Many revealing insights can be found by comparing the experiences of writing in a private journal, posting on a public bulletin board, publishing an article ... and posting on electronic media.

Biographies: Biographies can illuminate both the technical developments of the computer age and the social issues arising from these developments.

Technical Developments

Pascal's mechanical calculator and Charles Babbage's mechanical computer are early examples of how human thought processes can be "incarnated" into technological devices. Ada Lovelace, who collaborated with Babbage in developing the capacities of the new instrument, introduced the idea of a sequence of procedural steps, or *algorithm*, to accomplish a task.

The development of computation and cryptography during World War II is a fascinating subject. Alan Turing envisioned a general-purpose computing machine, proposed the Turing Test, and worked at the codebreaking center at Bletchley Park in the UK.¹⁷ Admiral Grace Murray Hopper, a leader in the development of early programming languages and related tools, significantly advanced techniques of programming during that same era.¹⁸

Related Social Issues

There are numerous important social issues connected to the rise of computers. First of all, computers are innately amoral: that is, they are incapable of making moral judgments, which means that the responsibility for their use falls directly upon us, their creators and users. This is true of all science and technology. For example, many jobs, especially those based on repetitive manual tasks, are disappearing. What is the responsibility of a society and its technological innovators to predict and to alleviate the consequences of such changes? Technology can have positive results, as well. Stephen Hawking is a moving example of the way new technologies

can enable a person to overcome a physical disability.

New technologies raise new ethical concerns. Examples can be given of unauthorized persons who gained access to information that was intended to be secret. Publication of such information can have significant social consequences. Students learn a great deal from wrestling with the consequential moral questions surrounding the activities of individuals such as Julian Assange and Chelsea Manning, organizations such as WikiLeaks and the NSA, and laws (e.g., the Patriot Act) enacted for the enhancement of homeland security.

Diversity is another pressing social issue which can be studied with respect to the use and creation of technology. The importance of women's early contributions to computing can be highlighted through the stories of Ada Lovelace, who is celebrated as the first programmer, Admiral Grace Murray Hopper, and the early NASA engineers whose story is told in the film *Hidden Figures* (Dir. Theodore Melfi, 2016).

Activists such as Richard Tapia and Anita Borg have worked to improve the relatively low level of social diversity within the field of computing. Other contributors include Brenda Laurel and her pioneering work in making games girls want to play and Leah Buechley and her innovations in electronic textiles, which she showed are accessible and appealing to women and girls.

Putting Technology Education into Practice

The curriculum laid out above is organized around our students' needs and opportunities. Some parts of this curriculum require technological tools (and someone who can maintain and understand them) as well as guidance and training for teachers.¹⁹

Many tools and sample curricula are readily available. The Computer Science Unplugged curriculum²⁰ offers a very accessible set of lesson plans for introducing computational thinking to upper elementary school children without any screen time.²¹ The Computer Science Teachers Association has published a series of essays on K-8 learning opportunities²² and an excellent reading list of relevant research²³ (especially for girls²⁴). Specific projects can be found in books such as *Sew Electric* (which has projects such as an LED bookmark book light, a sparkling bracelet,

and an interactive stuffed monster) and the *Invent to Learn Guide to 3D Printing in the Classroom*. (Projects include making custom tangrams, a fan- powered car, a two-gear clock, and connectors for the creation of three-dimensional polyhedra.)

Popular computational environments include Alice²⁵ (a virtual world programming

environment with low barriers to entry, which can be used to do project-based science and math,²⁶ narrative design²⁷ or even social science²⁸), Scratch²⁹ (a graphical programming environment with very low barriers to entry and a large community of learners who share programs), and Lego Mindstorms³⁰ (a robotic construction + programming kit). Easy environments which provide embedded curricula include Gidgets,³¹ a game which teaches programming and debugging. The E-nable community foundation³² has created a curriculum around the creation of prosthetic hands.³³ The online Python Tutor³⁴ lets you experiment with and visualize code.

[C]omputers are innately amoral: that is, they are incapable of making moral judgments, which means that the responsibility for their use falls directly upon us, their creators and users. This is true of all science and technology.

ENDNOTES

- 1 The *Cybercivics Curriculum* (www.cybercivics.com), designed for sixth to eighth graders, addresses social issues arising from the use of digital media.
- 2 Kafai, Y., Fields, D. & Searle, K. "Making connections across disciplines in high school e-textile workshops," in L. Buechley, K. Peppler, M. Eisenberg & Y. Kafai (eds.), *Textile messages: Dispatches from the world of e-textiles and education* (Peter Lang 2013), Chapter 6, p. 85.
- 3 The film *Screenagers* (Dir. Delaney Ruston 2016) is suitable for this purpose.
- 4 Duncan, C., Bell, T., & Tanimoto, S. "Should your 8-year-old learn coding?" In *Proceedings of the 9th workshop in primary and secondary computing education* (2014), pp. 60-69, dl.acm.org.
- 5 See Michael Seifert's online physics curriculum at www.waldorfteacherresources.com.
- 6 One of the authors had students build a 3D printer from a kit and then use it to print parts for a mechanism (see the e-Nable curriculum: <http://enablingthefuture.org/e-nabling-education-%E2%80%A2-curriculum-and-resources/>). Through this, they learned to see how an object can be visualized in layers and generated through motion in orthogonal (x-y-z) coordinates.
- 7 The CS Unplugged curriculum (www.csunplugged.org) offers age-appropriate exercises introducing topics such as binary numbers, searching and sorting, path-finding, and distributed networking.
- 8 In after-school clubs, one of the authors has helped students of this age to create simple programs that control a circuit or produce a 3D model.
- 9 Sewn-circuit projects can be found in the book and website *Sew electric*, Leah Buechley, Kanjun Qiu, and Sonja de Boer (HLT Press, 2013), www.sewelectric.org, and in many online sources.
- 10 www.rubegoldberg.com
- 11 See this NYT article comparing Luther's skill to that of today's Twitter users: www.nytimes.com/2016/10/30/arts/design/long-before-twitter-martin-luther-was-a-media-pioneer.html
- 12 See The CS Unplugged curriculum: www.csunplugged.org.
- 13 scratch.mit.edu
- 14 www.raspberrypi.org/learning/teachers-guide/
- 15 The e-nable community has developed an extensive, field-tested curriculum around this opportunity (<http://enablingthefuture.org/e-nabling-education-%E2%80%A2-curriculum-and-resources/>), and provides much support as well.
- 16 Anti-Phishing Phil is a game that covers some of these concepts: www.ucl.ac.uk/cert/antiphishing/
- 17 *The Imitation Game* (Dir. Morten Tyldum, 2014), a movie about Alan Turing adapted from Andrew Hodges' biography *Alan Turing: The enigma*, is appropriate for eighth graders.
- 18 Useful biographies can be found in Steven Levy's *Hackers: Heroes of the computer revolution* (Garden City, NY: Doubleday, 1984), which also provides a helpful introduction to the history of personal computing, and Howard Rheingold's *Tools for thought* (www.rheingold.com/texts/tft/).
- 19 Op. cit., Duncan, Bell and Tanimoto.
- 20 <http://csunplugged.org/>
- 21 An example can be seen at <https://www.youtube.com/watch?v=WforXEBMm5k>
- 22 https://csta.acm.org/Curriculum/sub/CurrFiles/CS_K-8_Building_a_Foundation.pdf
- 23 https://csta.acm.org/Curriculum/sub/CurrFiles/K-8CSReadingList_Research.pdf
- 24 <http://www.jstor.org/stable/4137437>
- 25 <http://www.alice.org/>
- 26 <http://www.cs.duke.edu/csed/rodger/papers/cse12.pdf>
- 27 <http://dl.acm.org/citation.cfm?id=1227418&dl=ACM&coll=DL&CFID=134150345&CFTOKEN=38055381>
- 28 <http://www.cs.duke.edu/csed/rodger/papers/cse09alice.pdf>
- 29 <https://scratch.mit.edu/>
- 30 <http://www.lego.com/en-us/mindstorms>
- 31 <http://www.helpgidget.org/>
- 32 <http://www.enablecommunityfoundation.org/>
- 33 <http://enablingthefuture.org/e-nabling-education-%E2%80%A2-curriculum-and-resources/>
- 34 <http://pythontutor.com/visualize.html>

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Teaching Computer Science in 11th Grade

Charles C. Weems

The cosmic forces thus utilized will lead to strange machines, but ones that will reduce human labor, since they will possess a certain intelligence. Cosmically oriented spiritual science will have the task of reducing harmful effects caused by the great temptations that arise from those mechanized beasts, which the people themselves have created. And we must add something else to all this: it is necessary for people to prepare by seeing reality for what it is, not as illusions—by truly viewing the world in a spiritual way.

— Rudolf Steiner, *Spirit Beings and the Ground of the World*, 3, Dornach, November 25, 1917

There is often a dramatic change in students between 10th and 11th grade with respect to their capacity to work with abstraction. In 9th grade, we consider computers concretely, working toward an understanding of what a computer is, and how it is fundamentally different from the human being. In 10th grade, we more actively engage the concrete aspects by dissecting computers, seeing how they are built, how they work, and how they are programmed at the lowest level. The content for teaching these courses can easily be learned by anyone with a background in math, logic, or the “maker” hobby.

In 11th grade, students start to look forward and outward into the world, and much of their world is online. They are denizens of the internet, and feel at home in it, even though they don’t fully understand it. Its virtual alternative to reality presents them with many temptations, mostly

of an illusory nature, and in this 11th grade computer science course, we begin preparing them to distinguish it from reality.

Rather than preaching about dangers on the internet, we can explain how it works and why. In the process, they can discover the means and motivations of people who use it to exploit others and the necessity of developing a new sense of morality to guide them. To teach this content, the teacher must delve more deeply into an understanding of the technology that stands behind the modern online world. This article, thus, begins with an overview of the relevant concepts.

One of the student’s most common experiences is performing a web search. But how could Google possibly search the entire internet in an instant to return links to hundreds of thousands of silly cat videos?

The answer is that it doesn’t. A search engine gets its data from a program called a web crawler that continuously follows links between web

sites, returning the pages to another program, called an indexer, that summarizes the data as a set of numerical values, somewhat like the call numbers in a library catalog.

Old copies of a page are kept (or “cached”), so that when a page is returned by the crawler, the indexer

can first look to see if anything has changed. The crawler runs on a vast number of computers at once, reindexing the web many times per day. That is why, when you put something on the internet and then delete it after having second thoughts, it may already have been indexed and cached, so it takes on an independent existence beyond your control.

Rather than preaching about dangers on the internet, we can explain how it works and why.

Because the web is already indexed, when we enter a search query, it is just a matter of generating index values from the words in the query and matching them to the recorded indexes. Each index value connects to the previously established list of pages that match, so it takes a fraction of a second to return the list. But the list we see isn't random. Pages in the list are ranked to give us the most relevant results first.

Students can identify many of the factors that can go into a page ranking: the number of other pages that link to a given page; the number of keywords on the page that match words in the search; how many times other users have gone to the page when it has been listed in search results (called click-throughs); the location of the searcher, etc.

In considering these, it becomes clear that manipulation of page ranking can be used to subtly alter a user's perception of the world. Google Bombs are obvious examples that illustrate exploitation of ranking. These are search terms that return unexpected results because someone has tricked the ranking algorithm into registering certain pages as more popular than others. For example, during a previous presidential election, the search "completely wrong" returned a large number of images of one of the candidates.

Ranking can also be used to favor certain online retailers, including those who pay for placement. A useful exercise is to do the same search using different search engines, such as Bing, DuckDuckGo, and Yandex. Many of their results will be similar, but some will be different. In some cases, different students will see different results from the same engine, which can be due to search history, geographical location of the computer on which the search is done, or the language the user usually uses when working with this computer.

Why are search results individualized? In part, to maximize effectiveness of advertising. When a search company can claim a higher rate of click-throughs, they can sell more ad space. More relevant results also keep users coming back. But they also lead to users seeing information that is compatible with their existing world view, which tends to reinforce their beliefs.

The result can be what some psychologists call "cognitive bubbles." A person is tempted to believe that a one-sided perspective is reality because their searches avoid sites with alternative views. Some of the current polarization in politics has been attributed to

this effect, and it can be seen as dividing people against each other into more narrowly defined identity groups. Students should see that they must develop skills to distinguish reality as it is from the illusory reality that is served up to them by online services.

The experience of seeing different rankings shows why it can be useful to go many pages deep into search results to find more diverse sources. This is also a good place to introduce advanced search methods and specialized searches, such as Google Scholar or Patents.

Students can be asked to combine more effective searching with their knowledge of social media, to discover as much information as possible about someone they know and make notes to report in class. A list on the board of the different types of information they find will grow to a considerable length. What is available can be quite surprising. The question of whether they want a college admissions office to have access to similar information about them provides some perspective. Searching for information on themselves, some students will discover that they already have a public presence that will follow them throughout life. Their online activity is creating a kind of "digital Akashic record."

When you put something on the internet and then delete it after having second thoughts, it may already have been indexed and cached, so it takes on an independent existence beyond your control.

A discussion of how consumers expect online services to be free, even when they are based on billions of dollars of investment, illuminates the challenges of creating a new web-based service, and why a common model for new companies is to develop and prove a service and then sell out to one of the established service providers. In many cases, much of the smaller companies' value is the data it has gathered on its users. Thus, when you provide information online, you don't know who may eventually end up with it, or how they will use or protect it.

Students may want to know how to guard their information online. Some may believe that careful use of privacy settings on social media protects them. However, some social media companies sell user information. Others have complex privacy settings that can be difficult to get right. And law enforcement can request personal information. Thus, some useful advice is not to post anything online that shouldn't appear on the front page of a newspaper.

A common belief is that "I don't have anything of value, and nobody would want to know about me, so I don't have to worry," otherwise known as "security through obscurity." But we never know where life will take us. An example is a congressional candidate whose opponent found a video of him doing a drunken dance in college and turned it into a TV campaign commercial.

To understand the basis for internet exploits, it helps to examine how the internet actually works. We can take students on a tour of the school's network equipment, explaining the various kinds of connections and devices that are encountered. Based on what they observe, students can map the school's internal network.

Even for a very simple network, it will be clear that data from many users are combined before being sent to the internet, because at least one of the devices will have multiple connections coming into it from around the school, and one connection that goes out toward the street. The external connection goes to the school's internet service provider (ISP), which has connections

coming to it from many customers in the same area. The ISP sends data over major connections that link to other cities and even other countries. Eventually, a message will find its way down through a similar network on the other end to a specific recipient.

One can then ask students for their ideas about how they would make such a system work. They quickly realize that each end point needs an address, and each message needs to specify a destination address and give its return address.¹ Sending messages back and forth is thus analogous to sending letters through the postal system.

Each message has a section containing the addresses (like the envelope that surrounds a letter) and a section containing the content.² Anyone can read the content at any point along the way, so it should be encrypted (with a secret code) to keep it private. And because messages contain return addresses, they can be tracked back to their origin.

For physical, wired, end points, it's easy to envision how addresses could be assigned from a central authority (just as town hall assigns street addresses). But what about mobile devices? In addition to the permanent addresses, we need changeable addresses. A mobile device will request a temporary address from a wireless base station,³ which has a limited number that it can hand out at any given time.⁴ The base station can thus run out of addresses if too many devices request them, which is why it can be difficult to get a connection in a coffee shop where many people are online. The base station recycles the address when the device moves on.

In our mail analogy, you can think of these addresses like the room numbers at a hotel. When you're staying at a hotel, you can have someone send you a package using your room number. But after you check out, someone else can check in and use the same room number.

With wireless in a coffee shop, where the owners may not be careful about the setup, this arrangement can allow a hacker to set up

a wireless station with a stronger signal that overrides the shop's station, and then hand out fake addresses so that messages can be intercepted by his or her computer, with the goal to detect valuable information, such as credit card numbers or user names and passwords.

The internet has many interconnected devices—computers, phones, remote controlled light bulbs—and information must be routed between them according to their addresses. Switches are specialized computers that receive a message from one connection, and send it out on another connection that will get it closer to its destination. More advanced models can be reprogrammed remotely. Thus, there is the potential for hackers to break into switches and install “sniffer” software, enabling them to spy on messages as they pass through.

Students should see from this and the coffeshop example that it is important to know how to determine when a website uses an encrypted connection, how to set email to use encryption, and, if they have a wireless base station at home, how to ensure that it is secure. It is worthwhile to have a discussion of how the internet is not heavily policed, due to the vast amount of data it carries and comparative lack of law enforcement resources for investigating online crime; thus uninformed users are often unprotected from the many unscrupulous people who invest considerable effort into taking advantage of them.

In addition to the address of a device, a message has to specify the application or service on the device that should receive it. For example, an email application sends a request to download mail from an email service, which sends the response back to the email application on the user's computer, rather than the web browser. Each message thus specifies both the destination address (the device) and the application or service to receive it.⁵

Because computers most easily work with numbers, an internet address is represented by a number.⁶ But we don't access sites by number.

We use a domain name, such as apple.com. The trailing letters of a name (.com, .edu, .de, etc.) specify its domain, that is, one of the established major types of internet address. When we enter a web site name in a browser, it is translated to a number using the internet equivalent of a phone directory.⁷

First the name is sent to one of a dozen organizations that manage all the names in the directory. That organization sends the browser to another that handles the names for a given domain. It may redirect the lookup to yet another that finally responds with the specific number sought.

Your computer also keeps a list, called a cache, of common and recently accessed addresses. The master directory is updated every fifteen minutes or so, as web addresses are added or changed, but your computer doesn't update its cache as often. When a computer or phone has been offline for a while, there may be a delay while it downloads an updated directory.

The directory system poses a security risk in that a hacked name lookup server can be set to translate a name to a different and possibly malicious destination. For example, in connecting to your bank, a hacked server sends you to a site that looks like your bank, but it steals your username and password. While rare for the big, public servers, a company that runs its own name lookup service internally may not have the same level of security. A more common scenario is that a link in an email or on a web page can look like a normal name (www.mybank.com) but the underlying address goes somewhere else. Students should learn how to inspect a link's actual destination before they click on it.

Students should also have a basic understanding of encryption, which relies on the idea that some mathematical functions are easy to compute but harder to undo. For example, we can multiply a chain of numbers (one of which represents a character in our message) quite easily to get a long number, but given a long number, it's more work to identify the numbers

that were multiplied to get it. If we have given the recipient the numbers in advance (a key to the encryption), then it is easy to divide them out and get our character as the remainder.

Encryption thus relies merely on the assumption that discovering the key is so time-consuming that nobody will invest the effort to do so for our messages. However, it's not impossible—there are government agencies with gigantic computers that can do the job in a reasonable time for select messages.

There is still the problem of sending the key to the recipient without anyone else seeing it. Two students can be given a lock box and a pair of padlocks, each with two keys. The goal is for one student to safely get their lock's key to the other. A little thought and experimentation results in the idea that one student puts their key in the box and locks it, then gives the box to the other student, who adds their lock to the box and returns it. The first student removes their own lock, and returns the locked box to the second student, who can unlock his or her own lock and open the box to get the key.

Key exchange is the basis for secure communication on the internet. But what if there is another student, with another pair of locks, between the first two? He or she can pretend to be the counterpart to each of them, and thus get both of their keys and open the box to read its contents before passing it on. This scenario is known as a "man in the middle attack."

How can you be sure the person you are exchanging keys with is not an imposter in the middle? You need a third party you trust. You give that person a key, and they provide a message back to you that says, "I confirm that it really is you who sent me this key," and which includes your key. But the message is encrypted so that nobody but the trusted person can read it.

When you contact the other person, as part of exchanging keys, you send them this message,

and they send it to the trusted third party, who decrypts it and compares the key it contains with the key you originally sent. If someone is trying to get between the two of you, using a fake confirmation message with their own key, it won't match the one that the third party has on file for you, and the third party can tell you this.

The internet has about 40 highly trusted organizations⁸ that are supposed to manage all of this. But that's too few organizations to handle all the key exchanges on the web. So their job is to certify a larger number of organizations,

such as major companies, that can handle the load. And they may in turn certify additional groups. In practice, we tend to rely on third or lower level organizations.

As complicated as that sounds, it comes down to establishing a chain of trust. Students should see that we need organizations we can trust to verify the identities of people and companies we connect with because we can't personally know

and develop trust with them ourselves.

But lower level organizations, for which certifying users is not a primary business, may not be as conscientious about checking identities. There have also been cases in which an upper level organization has been tricked through an extensive effort into certifying someone erroneously, as part of an espionage operation. In one case, the goal was to get computers to install an update that appeared to be from Microsoft, but the software⁹ actually allowed agents to secretly steal information from the computers on which it was installed.

Our exploration of how the internet works has been leading up to this basic truth: Digital data is divorced from reality. It can be manipulated to represent anything or anyone. A web page can be an honest representation of a business, but it can also be that a page comes up at the top of a search due to a manipulated search ranking and redirects the user to a site with a forged identity

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certification. The site may present the illusion of legitimacy and thereby tempts us to give up critical information.

There is no digital solution to the security problem. Encryption is not invulnerable, just costly to break. Identity certificates can be obtained by imposters. Passwords can be discovered with enough effort.

Security on the internet ultimately depends on people being careful.¹⁰ What happens if people fail to do their part? If identity thieves steal enough information about a person, they can get credit cards in that person's name and run up huge bills, file a false tax returns to steal refunds, access bank accounts and drain them, obtain government IDs in their names to use in committing crimes, and otherwise make life miserable for the persons affected.

But more often, hackers seek to take control of a computer. That may be a means of obtaining identity information, including stored passwords, or contact lists that can be exploited. But often it is to make use of the computer itself—to store illegal data that the hacker doesn't want to be caught with or to encrypt the data on the computer and then demand a ransom from the user to regain access.¹¹

A hacker may also install software that uses the computer to do his or her bidding. That could be sending spam email. Or it could become part of a coordinated army of compromised computers for carrying out online attacks on command.¹² Malicious software, called malware, comes in many forms, each with its own way of taking over a computer, which students should know how to defend against.¹³

One of the weakest points in computer security is the user. The "hack" of the Democratic National Committee during the 2016 presidential campaign and the theft of email, was the result of one campaign official's believing an email that told him his password needed to be changed

and he clicked on a link that went to a fake password reset page where he was asked to enter his existing password. The hacker immediately logged in with that password and took control of the machine. This unsophisticated but effective approach is generally known as "phishing." When carefully directed at a specific person, it is called "spear phishing."

Even without all of the technical trickery, sites can tempt us with a range of offerings. Free videos, music, games, apps, and illicit content are common lures. Students should consider how these sites support themselves. Some may do

so through advertising, but some collect information that can be sold or infect computers with malware.

One of the best defenses on the internet is to be skeptical of anything that appears to be free, or any message that tries to instill fear so we will take some action. Students should know that banks, credit card companies, the IRS, etc., will never send a link to a login page.

Some people think that if they create a false identity (mail account, social network account, etc.) with a different name, address, and so on, then they can use the internet anonymously to access illicit content, post controversial remarks on social and other media, engage in bullying, lure young people into harmful activities, etc. The possibility of anonymity can be empowering, but it can also bring out the worst in people.

However, it is very difficult to be truly anonymous on the internet. Return addresses in messages make it possible to trace their sources. The web is constantly monitored by software that has purposes ranging from improving the flow of messages to identifying shopping trends. Many sites, including search engines, track the places users are accessing to determine their interests and sell the data to advertisers.¹⁴

Google once ran a Super Bowl ad which showed a series of searches revealing a story of someone going on exchange to Paris, falling

There is no digital solution to the security problem. Security on the internet ultimately depends on people being careful.

in love, getting married, and having children. While most people thought it was cute, internet privacy experts saw it as chilling. Eric Schmidt, as chairman of Google, once said, “We know where you are and what you are doing, and we have a pretty good idea of what you are thinking.”

On the surface, the purpose of this portion of the class can be seen as educating students about why they must be careful on the internet, and how to avoid common traps. But one can also have a discussion of how technology calls us to rise to a higher moral standard while it gives us the potential for varying degrees of anonymity and power, tempts us in many ways to do things we might not otherwise consider, makes it possible for others to reveal our actions long after we may have forgotten them, and exposes us to a wide range of risks.

In the modern world, we cannot escape using the internet. We must develop a new level of consciousness around our actions so that our choices are thoughtfully guided from a moral basis. If we accept this challenge, then technology and the internet can actually be seen as helping us take the next step in the evolution of human consciousness.

The class can shift to a new focus: Why is it so hard to get software to work correctly? The first thing to discover is the challenge of expressing the solution to a problem algorithmically. For example, the teacher can pretend to be a robot that the students must direct to do some task, such as going to a fountain to get a drink of water. As the teacher gets stuck in corners, knocks furniture over, or otherwise turns his or her instructions into literal actions that were not anticipated, students learn the necessity of planning and expressing a sequence of steps carefully. They will also discover the limited vocabulary the robot responds to and devise ways to express repetition and possibly decision making.¹⁵ Students can discuss the experience

afterward and be invited to describe the change in mindset that it involved.

If there are computers available, the students can be given a simple program to implement. For example, they can start with the traditional ‘Hello World’ program, which pops up a message that greets them.¹⁶ Then they can extend the program to input some text that becomes part of the message.¹⁷ Once they have this working, they have most of the mechanics necessary to create a MadLib program.¹⁸ They can choose a story from a collection of Mad Lib books and build the program by replicating pieces of the

earlier program. It takes very little knowledge of programming to succeed because it is nearly all a matter of repeating a simple pattern.

The Mad Lib stories that are displayed can be exceptionally funny, and the students will take delight in trying each other’s creations. Along the way, however, they will discover

that a programming language is extremely strict and will refuse to compile a program if a single quotation mark or semicolon is out of place. Even after it runs, they often find that the spacing in their output is messy and that their use of line breaks is ragged. It takes quite a bit of effort to get everything just right, because the MadLib program, while conceptually simple, is long enough to have multiple errors.

That is, of course, the whole point. It’s not about learning a programming language, although it helps their comfort level to explain what each line of code does. Instead, it is having the experience of how much effort and attention to detail it takes to make software flawless. Once they appreciate this, it can be pointed out that the security of the internet depends on hundreds of millions of lines of code all working perfectly. Airliners, hospital equipment, the electric power grid, nuclear reactors, and many other life-critical systems depend on this same level of perfection.

It’s not about learning a programming language... [I]t is having the experience of how much effort and attention to detail it takes to make software flawless.

Hackers, on their end, will intensively examine code, looking for errors they can exploit.

The other aspect of the experience that the students encounter is that time seems to vanish while working on a program. After spending an entire period repeatedly compiling, fixing, and testing their code, when the bell goes off, many will express shock that the class is over.

Some will beg to stay and finish, revealing how programming can become addictive. The computer draws us into its world, made of simplified rules, which it seems we can completely master, unlike the real world. It gives us a feeling that here we have a powerful, yet slave-like machine into which we can place our intelligence, so that it becomes an active representation of our selves.

With some reflection, students should realize that creating a program can be a very egotistical experience. Yet, the best software is developed entirely with the user in mind. When software is hard to use, or contains obvious flaws, it is a sign of a programmer's ego overriding good judgment. Again, the technology calls us to rise to a new level, burning out our egotism, so that we are motivated by compassion for the people who will make use of our efforts.

Why do we have an internet? The purported purpose is communication, but to commune with another is to share thoughts and feelings even to a spiritual level. The idea that we can truly communicate using digital data is thus a materialistic illusion. But if we see the internet as a development that offers humanity regular opportunities to exercise a higher form of judgment and volition, then we grasp a spiritual reality that calls upon teachers to guide students in avoiding the temptations that arise from this beast and to respond to it in ways that lead them upward on the evolutionary path of humankind.

In twelfth grade, we will more deeply explore who we are with respect to our technology, as individuals and as a society, and then contrast human intelligence with artificial intelligence.

ENDNOTES

- 1 At this point, it's worth noting that the internet has many such conventions, called protocols. The one the students just reinvented is called the internet Protocol (IP), and the addresses are called IP addresses.
- 2 A message actually has three sections called the header, payload, and checksum. The checksum helps detect errors in transmission, much the way that a zip code is a double check of the city and state information on an envelope. The header contains not just the addresses, but also other control information, such as the length of the message and time it was sent. Payload is another name for the message content.
- 3 Also called a wireless router.
- 4 Permanent addresses are said to be "static" and changeable addresses are "dynamic." The Dynamic Host Configuration Protocol (DHCP) is responsible for handing out temporary IP addresses. When a mobile device requests an IP address from a base station, it uses DHCP to allocate one from a set it owns. When a device stops using the address, it gets recycled.

DHCP presents a potential security risk because a device with a stronger signal than the base station can pretend to be the base station and hand out addresses that cause messages to go through the device, allowing it to spy on them. Running the "traceroute" (Unix, MacOS) or "tracert" (Windows) network utility for a web address shows that traffic goes through many intermediate computers and switches.
- 5 Applications and services are assigned "port" numbers according to the terminal connect protocol (TCP). For example, email might use port 993, while the time service uses port 123, and a browser uses port 80. If IP addresses are analogous to street addresses, the TCP port is akin to an apartment number. The combination of the IP address and the TCP port number serve to uniquely identify the destination for a message. Thus, we often see references to the internet using TCP/IP. Most people do not use the majority of port numbers, since they only use a few applications. Even so, the convention is that the messages still need to be delivered, which could enable hackers to deposit malicious code into a computer's memory. Thus, operating systems allow users to selectively disable all of the numbers that are unused, setting up what is known as a firewall. Students should see how to check their computer's firewall settings.

- 6 The number is usually written in four parts. For example 17.178.96.59 is an address for Apple Inc. More recently, as the world has started to run out of numbers, we have started moving to IP version 6 (IPv6), which uses longer numbers, written in base 16. For example, 030a:74d5:f12c:1003:299b:8080:feed:0042.
- 7 The directory is called the Domain Name System (DNS). The internet has several hundred top-level DNS servers that are controlled by about a dozen different organizations that manage the registration of names. Each name is part of a domain (e.g., .com, .org, .edu, .uk, etc.)
- 8 These top level organizations are known as root certificate authorities; all they do is certify other major organizations as subsidiary certificate authorities. It costs quite a bit to become certified, so some organizations, such as smaller companies and schools, may declare themselves to be self-certified, and then they can issue certificates to computers within the organization to enable secure communications between them.
- 9 Malware called “flame.”
- 10 That means certificate authorities have to carefully check identities. Programmers have to write secure, bug-free code. Web sites must ensure they are using software that hasn’t been compromised. Users need to manage their security settings; watch carefully to ensure they are using encrypted communication with sites that have valid certificates and that links are legitimate before clicking on them; watch for unusual behavior on their computers that may be due to a virus infection; and much more. When students grasp the number of points of potential failure, and compare that to the effort that hackers are willing to invest in finding weaknesses, they will see why it is nearly impossible to avoid having data stolen. Thus, it is important to consider carefully the information they put online.
- 11 This is called encryption extortion, or ransomware.
- 12 The army is called a botnet, and it can be used to attack and shut down sites (perhaps for political reasons) by flooding them with requests called a “distributed denial of service,” or DDoS, attack.
- 13 More specifically, a virus is a piece of software that is run when files are shared. Like a real virus, it is spread

When students grasp the number of points of potential failure, and compare that to the effort that hackers are willing to invest in finding weaknesses, they will see why it is nearly impossible to avoid having data stolen. Thus, it is important to consider carefully the information they put online.

- by contact between infected machines. A Trojan horse is a program that seems to do one thing, such as giving the user a free computer game, but that infects the computer with malware when installed. A rootkit is malware that takes over the operating system at the deepest level, so it is impossible to remove without completely wiping the machine. A rootkit might include a keylogger, which records everything typed on the computer, sending passwords and credit card information to the hackers. A worm is malware that actively scans the internet for other computers that have security holes, such as open TCP ports, and then copies itself onto them, turning them into “zombies” that continue to spread the worm. Unlike a virus or a Trojan horse, a worm can infect a computer without requiring the user to do anything. Zero day exploits are security holes that the computer makers haven’t found and fixed. A nightmare scenario for computer security experts is a zero day exploit that enables rootkitting, and can be spread by a worm, since it could silently and rapidly infect millions of computers. In May of 2017, over 200,000 computers were infected in this manner with ransomware called WannaCry.
- 14 Browsers maintain caches of recently downloaded site content, history of accesses, and collections of files called “cookies” that enable sites to identify return visitors. Many browsers automatically share this information with their user’s other devices, so that, for example, an access from a phone can be easily resumed from a laptop, and a copy of all of it is held on a “cloud” system. Servers keep logs of all access attempts to help identify the sources of attacks. Even in “private browsing” mode, most computers expose enough information (make, model, operating system version, browser version, location) to have what is effectively a digital fingerprint that enables them to be tracked. There are tools that do enable people to be relatively anonymous, but they take considerable knowledge and effort to employ effectively. They are agnostic as to whether they are enabling criminal activity or free speech. If someone is investigating their use, it should be a trigger for reconsidering the motivation behind wanting to be an anonymous actor on the internet.

15 The basic organizing mechanisms for the instructions in an algorithm are sequence, branch, and loop. Because computers on the internet do different things at the same time, there is also a notion of instructions working in parallel, which has become an important aspect of programming. Coordinating parallel programs can be very challenging, as can be demonstrated by having two students work side by side at the board to quickly add one to numbers in a list. Very soon, it will be seen that they can't keep track of which ones have already been incremented, and so some will have two added by mistake. Learning to cope with this kind of interaction helps preserve a flexibility of thinking that can be lost if students are only taught to turn problem solutions into sequences of steps.

16 Here is a Java "Hello world" program:

```
import javax.swing.*
public class HelloWorld
{
    public static void main (String [] args)
    {
        JOptionPane.showMessageDialog(null,
            "Hello world");
    }
}
```

The BlueJ environment (www.bluej.org) is a free, student-oriented, Java development platform that works identically on Windows, MacOS, and Linux.

17 Extended program that inputs text to replace "world":

```
import javax.swing.*
public class HelloName
{
    public static void main (String [] args)
    {
        String name = JOptionPane.
showInputDialog("Enter a name: ");
        JOptionPane.showMessageDialog(null,
            "Hello " + name);
    }
}
```

18 An example of a very short MadLib-like program:

```
import javax.swing.*
public class MadLib
{
    public static void main (String [] args)
    {
        String adjective1 = JOptionPane.
showInputDialog("Enter an adjective: ");
        String noun1 = JOptionPane.
showInputDialog("Enter a noun: ");
        String verb1 = JOptionPane.
showInputDialog("Enter a verb: ");
        String adjective2 = JOptionPane.
showInputDialog("Enter an adjective: ");
        String noun2 = JOptionPane.
showInputDialog("Enter a noun: ");
        JOptionPane.showMessageDialog(null,
            "The " + adjective1 + " " + noun1 +
            " " + verb1 + " over the \n" +
            adjective2 + " " + noun2 +
            " and said, \"Oh my!\n\"");
    }
}
```

This program will ask the user to enter an adjective, a noun, a verb, an adjective, and a noun. If the user enters: "blue," "cow," "flew," "fat," and "donkey," it will output:

```
The blue cow flew over the fat donkey
and said, "Oh my!"
```

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Waldorf Pedagogy and Howard Gardner's Six Entry Points to Teaching for Understanding

Helen-Ann Ireland

Abstract

This article identifies synergies between the main lesson format of four Waldorf teachers and Howard Gardner's six entry points to teaching for understanding. Gardner identifies the entry points as narrative, esthetic, logical, experiential, foundational, and interpersonal and posits that using the entry points gives a variety of modalities for students to access a curriculum. This article examines how four Waldorf teachers were already using entry-point thinking in their lessons as part of an almost 100-year tradition in Steiner education and further explains why they thought using multiple modalities, or entry points, was important for student learning.

*B*ased on an unpublished, small-scale qualitative study that tracked the main lessons of four Waldorf teachers in their classrooms in the Fall of 2012, it becomes clear there is a synergy between what the Waldorf teachers are doing and Gardner's recent theory. Mapping Gardner's six entry points to teaching for understanding onto the main lesson content reveals a striking alignment between what was happening in these classrooms and Gardner's theory. In interviews, the teachers describe how the ultimate goal of their teaching methods is to help children unfold their full range of talents in preparation for higher learning and as a means to becoming citizens who can contribute in thoughtful, meaningful ways to society. Gardner posits this approach to teaching could be "revitalizing of the educational process" (Gardner 2004).

Rationale

One of the concerns in the current education debate concerns the narrowing of the curriculum as an unintended consequence of the focus on high-stakes testing. The research presented here is intended to shed light on an approach to teaching that closely corresponds with the way Waldorf educators have been teaching for close to 100 years and to further link their approach to current theory. Howard Gardner, Professor of Cognition and Education at Harvard's Graduate School of Education, has developed a theory about approaching a topic from multiple modalities, which resonated with my own experience as a Waldorf teacher who had been trained to use a variety of disciplines in approaching a curriculum topic. Intrigued by the similarities between the two approaches, I took on the study presented here in order to examine more closely the parallels between the Waldorf approach to teaching for understanding and Gardner's six entry points to teaching for understanding. It underscores the importance of using a multi-layered approach to teaching that expands exploration of a topic rather than narrowing the exploration.

Improving education in the United States has been the burning question for educators since the 1983 Reagan Administration report titled *A Nation at Risk*. Since the release of this report, there have been many attempts to reform the American education system. One increasingly popular focus has been on high-stakes standardized testing (NCLB 2001; RTTT 2009). However, many educators in public, private, and charter schools are concerned about an approach that puts the learning focus on student performance using high-stakes standardized

tests (Amrein-Beardsley 2014; Ravitch 2014). Many educators also have questions about the effects of “teaching to the test,” especially at the elementary level, and the narrowing of the curriculum that can occur with such an emphasis. Waldorf schools do not use high-stakes testing and, as will be demonstrated in the following pages, their teaching methods align with Gardner’s theory of using multiple entry points so that students can more fully understand a topic.

The underlying question driving this study concerns the purpose of an education. Are we educating so that our students have creative, synthetic, disciplined, respectful, and ethical minds so that all may be able to participate thoughtfully in a democracy (Gardner 2008; Labaree 2010; Steiner 1976)?

Alternatively, are we singularly focused on preparing students for a job market to compete in a global economy that may not exist when this year’s first graders graduate from college in 2033?

The real question is, “What are the capacities that the young need to develop in order to meet a future that is unknown?” This study posits a shift in focus from the dominant narrative on testing for education reform to teaching for understanding. While it is beyond the scope of this paper to provide evidence that students do reach a better understanding of a topic using this approach to teaching, it adds to the body of knowledge that already exists about effective teaching and for optimal student learning (Brooks and Brooks 1993/1999; Csikzentmihalyi 1996; Darling-Hammond 1995; Dewey 1934, 1938; Eisner 2002, Efland 2002; Gardner 2004, 2008; Harris 2000; Kolb 1975; Kress 1997, 2000; Marzano 2010; McIntosh 1992; New London Group 1996; Perkins 1986; Piaget 1969; Steiner 1919; Westwater & Wolf 2000; Wiggins and McTighe 2005; Vygotsky 1978).

The real question is, ‘What are the capacities that the young need to develop in order to meet a future that is unknown?’

Natural History of the Project

In January 2012, Howard Gardner delivered the Askwith Lectures at the Harvard Graduate School of Education, in which he revisited his learning theory about the entry points to teaching for understanding. In these lectures, he expanded the theory from five entry points to include a sixth. The six entry points are narrative, esthetic, logical, experiential, foundational, and interpersonal; Gardner (2004) asserts they can be used in teaching for a “revitalizing of the educational process.”

“Teaching for understanding” refocuses the educational conversation in the U.S. away from a test-based emphasis. When analyzing the definition of the word *understanding*, we find multiple meanings. As defined by Webster, *understanding* has several nuances: a mental grasp or comprehension; the ability to apprehend general relations; the power to make experience intelligible by applying concepts and categories; adjustment of differences; and a friendly or harmonious relationship. In other words, the term *understanding*

has both cognitive and social applications.

One may conclude that in order to address the multiple layers of understanding, there can and should be multiple access points to engage with curriculum content, offering a comprehensive and expansive way of teaching and learning. Just as there are multiple meanings to the word *understanding* in different contexts, so are there multiple understandings of a given topic from different vantage points—artistic, logical, social, kinesthetic, narrative, and existential (Gardner 2008).

Gardner states that any curriculum content can be approached from five or six vantage points to ensure that different students can find their way to engage the topic. “Awareness of these entry points can help the teacher introduce new materials in ways in which they can be grasped

by a wide range of students; then, as students explore the other entry points, they have the chance to develop those multiple perspectives that are the best antidote to stereotypical thinking” (Gardner 2004, p. 245). In the Waldorf classrooms observed in this study, it was clear that the teachers were already using the entry points with students of all ages and integrating these points into each subject even though they were unaware of Gardner’s theory at the outset of the study.

Methods

The study took place in the Fall of 2012. Classroom observations, interviews, and artifacts were collected during main lesson blocks from four teachers in grades one, three, five, and seven over the course of approximately eight weeks. Main lesson in a Waldorf classroom, which is taught during the first two hours of the day, explores a single subject through many modalities over the course of three to four weeks. It is an immersion in a subject that further connects it to other disciplines.

Field notes were coded and analyzed using grounded theory as described by Strauss and Corbin (2008) and Charmaz (2005). Through writing thick description and coding the teachers’ words, categories emerged that identified the goals that teachers were aiming at when using their entry points (Geertz 1973). The coding categories in the study were named differently from Gardner’s six entry points, yet in the analysis there was a striking alignment between the categories in the study and Gardner’s entry points. Interestingly, the teachers had no knowledge of Gardner’s theory prior to this study. It is the standard teaching approach that has been used in Waldorf classrooms for over ninety years, based on the indications of Rudolf Steiner (1919).

For full disclosure of my relationship to the study participants, I should mention that I am

a former Waldorf class teacher and therefore have an internal or emic viewpoint in this study. Being a semi-insider helped me understand the fundamentals of the Waldorf system, especially the construct of the main lesson, which is designed to incorporate multiple modalities in a daily two-hour lesson. I also knew two of the participants from attending teacher conferences prior to the mini-study. These relationships helped me gain access to their classes.

Findings

The Waldorf teachers exhibited what could be called “entry point thinking” as they planned their lessons. They wanted their students to explore the topics from a variety of vantage

points, not only to address the different learners in the group but also to expose all children to a variety of ways of studying a single topic. The teachers wanted to keep their students’ minds open to possibility, to support flexibility in their thinking for the purpose of grasping the complexity of the content, and to provide a tapestry of experience leading to a deep

and broad understanding of the content being presented. They wanted the children to use their senses, to be able to move their bodies, to use their imaginations, to think logically, to interact with each other and with the teacher, and to be creative. The teachers wanted to present a complex and comprehensive study of the curriculum topics. One example of this was the third grade teacher’s explanation for creating an esthetic, imaginative experience when studying the science of the sun. It drew on human sensory experience of the sun in addition to scientific facts.

... For some to say that the sun is just a ball of burning gas kills that picture and kills the sense of what the sun can be. On the other hand, yes, there are certain things we can measure

“Teaching for understanding” refocuses the educational conversation in the U.S. away from a test-based emphasis.

about the sun and we know that there are gasses in there that when they get hot enough they can burn. The sun is also something else. Think about yourself on a really cold, miserable day when all of a sudden the sun breaks through the clouds and you see this sunbeam shining through or you see a rainbow and it makes you think, “Oh that is so beautiful.” Your feelings change. Or you’re feeling really cold and miserable and you wish somehow that winter was over and then you get a warm sunny day. You find a corner protected from the wind and feel the warm sun on your face. That is part of the experience of the sun, too. (Third grade teacher interview, 2012)

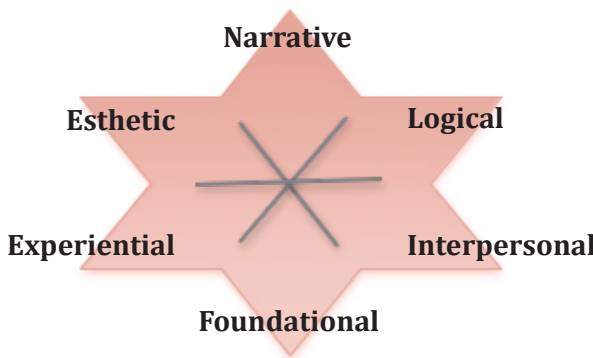
What was so striking about this study was the relationship between what Gardner has identified as the six entry points to teaching for understanding and what the teachers were doing in their classrooms. The teachers felt that concentrating on a topic allowed them to develop an in-depth exploration of the subject and integrate other disciplines related to the subject. For example, in studying astronomy, one of the teachers introduced poetry about the moon and stars, geometry of the circle by looking at the horizon and the zenith, and the biographies of relevant scientists (Copernicus, Galileo, and Tycho Brahe). Though the topic was astronomy—a science—the teacher incorporated poetry for an esthetic experience, body movements for sensing the geometry component, and biographies for a narrative component.

During analysis, categories identified through micro-coding emerged that complemented, linked, and described reasons for the six entry points. Their collective story was one of engagement—how the children engaged in their learning through imagining, interacting, thinking, sensing, moving, and creating. The coding connected in most respects to Gardner’s six entry points. There were esthetic, narrative, logical, kinesthetic, foundational, and interpersonal aspects in each main lesson observed for

the purpose of stimulating the imagination, providing possibilities for interacting, sensing the unknowable, experiencing through physical and mental movement, and using individual creativity for reflection and developing esthetics.

Gardner’s Six Entry Points to Teaching for Understanding

Esthetic: Esthetic is the first point identified in the study. As Gardner (1995/2004) describes this, “the emphasis falls on the sensory or surface features” of the teaching approach (Gardner, p. 246). He gives several examples of possible entry points, including visual and musical ones. In the study, a connection could be made to the category called *creating*. The teachers were expecting the children to create in a variety of ways. *Creating* in this sense means to “bring into existence; to design or produce through imaginative skill” (Webster 2016). In this category, the children were involved in creating esthetic experiences throughout the morning. All grades created music together by singing and playing recorders, reciting poetry, drawing illustrations of fairy tales (first grade), human shelters (third grade), the map of India (fifth grade), and the phases of the moon (seventh grade). All classes were engaged in writing and creating their own main lesson books as a record of the lessons in the block. By planning to have music, poetry, and drawing relate to the curriculum content or season, the teachers were providing esthetic



Gardner 2004, 2012, with visual by Ireland 2016

experiences related to the curriculum topics. One teacher related the esthetic experience to the creation of beauty.

The idea that the world is beautiful is important. We don't really talk about this, but over the years we build that up so they have this experience that when I stand with a group of people I can create something beautiful with my voice in singing or I can create artistically something in the visual realm with drawing or painting... (Fifth grade teacher)

Through the esthetic entry point as defined by Gardner—addressing students who prefer an artistic approach to a topic—the teachers were involving the students in creative activities that were esthetic in nature. Each of the grades observed recited poetry, sang, drew, and wrote in their main lesson books. These were features of the morning lessons in each grade. The students could create beauty through esthetic experiences.

Narrative: The next approach Gardner identifies is the narrative—stories or content delivered orally. In the study, this relates to the category *imagining*, because the teachers were engaging the students' imaginations through their storytelling—the narrative approach used to explore the curriculum content in Waldorf classrooms. To imagine means “to create mental pictures or to think of or create in your mind” (Webster 2016). Storytelling is one of the ways

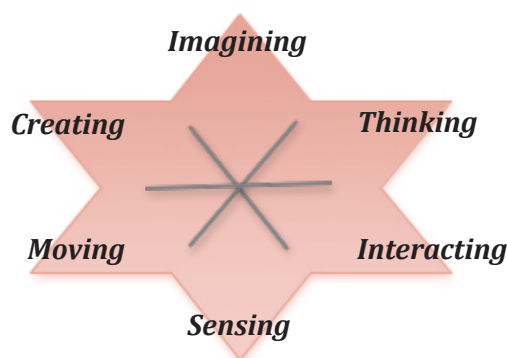
these teachers provided the opportunity for students to use their own imagination to create mental pictures while they told the story in the form of fairytale, myth, or biography.

In the first grade the teacher told the story of the “Fisherman and His Wife.” In the third grade the teacher had just finished telling the story of Cain and Abel and their need for shelter as an introduction to the Shelters Block (a study of human shelters from the primitive to the modern and from a variety of cultures). The fifth grade teacher was telling the saga of the “Ramayana” from Indian mythology, and the seventh grade teacher was telling the biography of Tycho Brahe to link history with astronomy. In all cases the children sat and listened quietly as the teacher narrated the stories. As an observer, I realized that I was making mental pictures as I was listening along with the children. It occurred to me that they were probably doing the same thing.

In their interviews, the teachers stressed the importance of letting the children use their own imaginations as a pathway to creative thinking. The teachers explained that they used the narrative as one way to foster the ability to *imagine*, which means to create inner pictures:

If you can't imagine it, you can't play with the ideas. If you don't have the imagination, how can we expect to take it a step further in your mind's eye? Theoretical physics is in line with the first grade fairytales and reviews. It calls upon the same kind of imagination—being able to move some thought around in your mind.... Atoms behave this way, but can they behave another way? Do you see the correlation between cultivating imagination in first grade and being able to imagine atomic particles in high school? (First grade teacher)

By narrating curriculum content, the children create mental images that allow them to see the story unfold in their imagination. “We use the narrative as a way to interact.... [W]e use



Ireland 2016

the narrative to bring experience through the experience of other people, but the students make it their own. They can feel what the other person may have been experiencing" (Seventh grade teacher).

All teachers in this study used the narrative approach as defined by Gardner to inspire the imagination of the children. They each told stories from the curriculum designated by Steiner (1919) as appropriate for the developmental age of the children. The stories, ranging from fairytales to Old Testament, from Ramayana to biographies of astronomers, were used as springboards for the esthetic experience along with poetry, songs, movement, drawing, and writing connected to the narrative themes of the grade.

Logical-Quantitative: Teachers had a logical or mathematical component in their lesson, regardless of the curriculum topic. As Gardner describes it, "One approaches the concept by invoking numerical considerations or deductive reasoning processes" (p. 245). For the teachers, this category was about *thinking* through a numerical situation. *Thinking* in these terms means to have the process of logical thought (Webster 2016). Logical (mathematical and scientific) thought was woven into each lesson as an integral part of the morning, even if it was not the primary focus of the block. The teachers wanted the students to be able to follow a line of mathematical or geometrical thought and either calculate, record, or recite patterns in and out of order while, for example, reciting the times tables.

The first graders were asked to use their periwinkle shells and, working with a partner, were given a series of addition and subtraction problems to solve using their number facts from one to ten. The third graders were given a set of

simple division problems for their morning warm-up work, with increasingly more challenging problems as bonuses. They were also working with number patterns via the times tables and reciting them in unison from memory. The fifth graders were asked to use their knowledge of fractions to mentally triple a recipe that they

would be using for baking apple crisp. Later they were given some other numerical problems to solve using paper and pencil. The seventh graders had just finished a block in geometry and were asked to show 90, 180, and 360 degrees with their arms. Later in the lesson, they were asked what was wrong with a statement the teacher had

made about the Big Dipper moving in the night sky? The students had to use their knowledge of astronomy to decipher the error. After several minutes, hands went up in the air: "The stars are not actually moving; the earth is" (Classroom observation, 2012).

Experiential: Gardner explains that this entry point allows students to work directly with materials that embody or convey a concept. Gardner's experiential entry point corresponds to the *moving* category in the study. The teachers in these classrooms provided authentic experiences and to get the children moving their minds and bodies to experience certain mathematical and scientific concepts. The teachers had the children involved in every type of experience: hands-on (working directly with materials, including drawing), kinesthetic, mental math, and whole-body movement in math and science.

Hands-on and practical, real-life experiences were part of the lessons. Math in first grade involved periwinkle shells as counters to provide tactile engagement and hands-on manipulation of materials while working with number stories. The third graders collected newly-laid eggs and kept a tally of how many eggs the hens were laying.

[W]e use the narrative to bring experience through the experience of other people, but the students make it their own. They can feel what the other person may have been experiencing.

The fifth grade teacher used the experience of baking apple crisp for the school as a basis for a math lesson. Her students were also counting in Hindi, doing yoga poses, and learning an Indian marching technique (*kalari pyattu*) to have an authentic experience of what it might be like to live in India. The seventh graders were asked to move their arms in 90, 180, and 360 degrees to feel the arc of the horizon compared to the zenith.

Experiential learning also included movement activities ranging from the artistic (class play, doing yoga, and *kalari pyattu* marching) to the mathematical and the scientific. The teachers stated that in addition to providing materials with which to interact, learning in some subjects could be enhanced by movement; they used this technique regularly when teaching the times tables, for example. Using clapping patterns and rhythmic movement helps the children integrate knowledge through a kinesthetic experience. “Waldorf teachers want the children to feel the variety of their own movement; that they can control it; that they can move fast or slowly, jump up or crouch down with the imaginations of the words [recited in poems]” (Third grade teacher).

Learning through experience was observed in every classroom. This included students moving in various ways to experience number patterns, a different culture, or body geometry related to the cosmos. Drawing offered another kind of experience. All students created a main lesson book in a portfolio-style compilation of their work from the main lesson content. The teachers said that the drawing assignments were used as a way for students to have a hands-on or experiential entry point to the subject studied. “Learning is a dynamic process... everything needs to be felt and experienced” (First grade teacher).

Interpersonal: In this section, the interpersonal entry point is interpreted broadly to include cognitive, esthetic, social, and collaborative

activities. In the study, the category that corresponds to Gardner’s interpersonal entry point was *interacting*. The lessons involved interpersonal and collaborative work, except when the students were drawing, writing, or doing individual mathematical calculations with paper and pencil in fifth grade, for example. All of the recitation, singing, recorder playing, morning circle movement activities, and games involved interaction and collaboration.

In first grade, the math was done in pairs so students could help each other work out the problems. In third grade, the review of the lesson on house building required active listening to participate in the dialogue. In fifth grade, the teacher had the students lead the class in the sun salutations and the Indian marching technique while they counted in Hindi.

Group work was paramount to the learning experience in these classrooms. “A lot of our day is social in the sense that we do so much together” (Fifth grade teacher). The seventh grade teacher had this to say about the interpersonal, which the teacher described as “the social”: “The social to me is what makes this alive... [E]ducation is stepping into the human experience. It is not a hermit experience. Real learning comes between people. It comes from the ‘give and take’ and the exchange” (Seventh grade teacher). The first grade teacher added, “There is a social component to everything we do... the social is huge” (First grade teacher).

Several teachers said that school provides consistency and predictability, while teachers facilitate collaboration and interpersonal relationships that foster teamwork and learning. Cooperation rather than competition was stressed in the classrooms of these Waldorf teachers. The third grade teacher explained working with the interpersonal in the classroom this way: “It’s sort of like conducting an orchestra. You need the sense when you are teaching to the individual, when you have the soloist, and when

Cooperation rather than competition was stressed in the classrooms of these Waldorf teachers.

you are dealing with the whole orchestra—the whole class moving together and such. When you are dealing with sections of the orchestra—the violins—and working back and forth between the individuals, small groups, and the whole group” (Third grade teacher).

One of the clearest examples of interpersonal collaboration happened in the fifth grade. The class was preparing to put on a play based on a section of the *Ramayana*. The teacher had been telling the story for weeks, and the children were learning their lines for their upcoming play and rehearsing sections during the main lesson. Some students were “on stage” (desks had been moved to the side of the room), while others were waiting patiently for their turn and became the audience for their classmates. At one point the whole class practiced the vigorous marching they would be doing. They formed lines and began moving across the “stage.” Coordination of leg and foot movements and staying together in a line were all elements the students worked with as they practiced this kind of marching for their play.

Foundational and Philosophical: The foundational as described by Gardner encompasses the philosophical questions that naturally arise in childhood throughout their growing years. In the study, the category correlating to this entry point was *sensing*. In this case the word *sensing* is used to denote “clear and sound mental faculties; faculty of the mind analogous to sensation or moral sense” (Webster 2016). The teachers encouraged the students to have a feeling sense for existential questions. In every classroom, philosophical questions were addressed directly or indirectly in the lessons observed. In the interviews, it was clear that the teachers welcomed these questions and interactions with their students and, in fact,

The teachers described this as one of the hallmarks of their teaching—that the curriculum helped the children wrestle with the great moral and ethical questions that face human beings.

made philosophical questioning part of the daily review of the lessons. The teachers described this as one of the hallmarks of their teaching—that the curriculum helped the children wrestle with the great moral and ethical questions that face human beings. They said these issues could be raised through the grand narratives—using the traditional stories from many cultures to probe these questions.

Beginning in first grade, when reviewing the story “The Fisherman and His Wife,” the teacher fielded the moral question about never

being satisfied with what you have. The children were able to discuss this simplistic yet profound issue of greed and what happens to people who think only about themselves. In third grade, the story of Cain and Abel has its own moral lessons that the teacher discussed with the children—for instance, how one’s hatred and jealousy can drive one to commit horrible

acts. In fifth grade, the story of Sita and Ravenna had the children wrestling with the mighty issues of faithfulness and betrayal, courage and cowardice. In seventh grade, the story of Galileo and his struggle with the Roman Catholic Church brought to the students’ awareness the idea of standing by one’s convictions. Where would we be today if Galileo had not pressed on with his studies of the heavens despite being called a heretic? All of these stories provide the fodder for rich discussion with the children as they begin to weigh the consequences of human action in the world.

The philosophical is also brought out through poetry and the sciences taught in conjunction with one another.

I can speak about the unknowable in the context of science. I can use science to create a metaphor that there is something larger than us. I had an experience when I was watching

the students watch the clouds one day. They could hardly grapple with the beauty. And poetry comes of the experience of being in relationship to something you are learning about but is so beyond what you can add up in a formula. The only way to express it is through art. (Seventh grade teacher)

The fifth graders were learning a passage from the *Rig Veda* that helps them ponder the great unknowns through the eyes of Indian mystics:

*There was not non-existence nor existence.
There was no air, no sky beyond it.*

What covered it and where? And what gave it shelter? Was water there, unfathomed depth of water?

Death was not then, nor was there aught immortal. No sign was there, day's and night's dividers.

That one thing, breathless, breathed by its own nature.

Darkness, there was; at first concealed in darkness.

And ALL was indiscriminate chaos. All that existed then was void and formless.

By the power of warmth was born the Sole One.

With the help of the teacher, expressed thoughts like the ones above inspire the children to ponder the great unknowns, ask the existential questions, and contemplate the human experience. “The artistic, poetry and music, to me, reflect the other side of the scientific experience. It brings the other side of the science. It is the other way that human beings make sense of the world” (Seventh grade teacher).

Weaving Entry Points in the Waldorf Classrooms

An underlying theme woven through all the lessons was *integration*. Every lesson observed utilized all six of Gardner’s entry points, and it was difficult to separate them as discrete points in the lessons. The teachers were integrating aspects of the entry points in combinations that they felt enhanced the level of the children’s engagement. Every teacher began the morning by involving the whole class in movement activities, but they also integrated mathematical, poetical, musical, dramatic, and topical activities—topical meaning related to the main lesson topic, e.g., doing yoga when studying India. Activities were integrated and related to the curriculum topic so that each topic was approached from a variety of entry points.

The integration continued throughout the morning. During the review of the previous day’s lesson, existential questions were asked and whole class discussions ensued with the teachers carefully guiding open-ended conversations on the topic. Later in the lesson, the students were asked to use drawing and writing as tools for deeper reflection on the topic, engaging the imagination and activating esthetic sensitivity.

The visual arts, music, poetry, movement, and storytelling were integral components of all the lessons across grade levels. Not only did the children experience several entry points on each topic studied, but the teachers also made it clear that this was planned to bring about a deep understanding of the curriculum content from many perspectives. The teachers described their work as being artists who create main lessons to address the cognitive, emotional, and physical development of the children at their stage of maturity.

Webster’s dictionary defines *creativity* as the ability to bring into being, to produce through artistic or imaginative effort, and that an artist is a creator of artistic work (Webster 2013). These teachers were asking the children to become artists, too. They expected their children

to become poets, musicians, visual artists, dramatists, and writers. These experiences were woven into every unit of study observed and into the daily rhythm or routine of the main lesson, so that they became a natural part of the day. All the children participated in every activity to the best of their ability.

One teacher described a moment when the children were showing their drawings of the previous day's narrative to one another. "The drawings of the stories were marvelous. They were so proud of them. Each one was different, and they came up with all sorts of things. They each displayed theirs for their classmates to see" (First grade teacher).

One teacher related the reason why teachers involve so many sensory and creative experiences in their lessons. "I think this tutoring of the different senses in order to make it possible for the children to be able to have qualities, or skills rather, that are not dependent on technology to make them work has become more of a critical piece. I think we are at a point where deficiencies are lax in that way and can be unnoticed. I think the auditory learning is such a strong facet of the way we teach" (Third grade teacher).

Discussion

Through the study, it became clear that the teachers at this Waldorf school were already using all of Gardner's entry points to bring understanding to a topic. The teachers were also utilizing the many dimensions of the children's abilities in the lessons; their cognitive, affective, and physical development were taken into consideration at every grade level. Reciting poetry, singing, playing recorders, and using rhythmical movement to recite times tables, for example, were active practices in every classroom observed. The teachers expressed

The teachers ... believed that using multiple entry points fosters creative, imaginative, moral thinking and leads to a deep and broad understanding of the curriculum content; it also helps the children make connections in and between disciplines.

the sentiment that they wished the children to be able to ponder the great unknowns, to use their thinking to solve problems, to be creative and use their imaginations in their work. The teachers in this study believed that using multiple entry points fosters creative, imaginative, moral

thinking and leads to a deep and broad understanding of the curriculum content; it also helps the children make connections in and between disciplines. This supports Gardner's claim that "deep immersion is key to understanding" (Askwith lecture, January 2012), and that efforts to "develop those multiple perspectives... are the best antidote to stereotypical thinking" (Gardner 2004, p. 245). The teachers in this study concurred that they wished to develop flexibility and creativity

in the child's thinking through utilizing multiple modalities.

Significance and Future Directions

This small-scale study provides a model of teaching for understanding that is currently in use. It is an approach similar to constructivism and universal design that strives to engage students to learn in ways that use multiple entry points to address the depth and breadth of a topic and provide access for a variety of students. It would be interesting to take the next step and see if this approach to teaching makes a difference in understanding a topic. Intuitively this makes sense. This method of teaching is common practice in Waldorf classrooms and could be used for further study to begin to address what happens to children's thinking, creativity, and imagination when the curriculum gets narrowed, for example, in some public school classrooms faced with the emphasis on high-stakes standardized testing. The study also raises several questions about depth of

understanding and fostering moral thinking as ways to prepare students to become citizens in a complex world.

This study raises questions about the integral use of the arts—in particular the visual arts—to augment understanding. To date there have been some studies conducted on the effects of drawing on the brain—for instance, by the Dana Consortium (Gazzaniga 2008). We also know from the work of Eisner, Efland, and others how the visual arts affect learning by helping to create habits of mind (Efland 2002; Eisner 2002; Hetland, Winner, Veneema & Sheriden 2007). A question that requires further study is how does daily, curriculum-embedded drawing as used by these Waldorf teachers affect student understanding?

More could be done to study each of the entry points alone or in combination to pursue deep understanding. We could ask of movement activities, drama, speech, music, and poetry: Does each of these esthetic and experiential approaches contribute to deeper understanding and help make interdisciplinary connections, as the seventh grade teacher suggested in reference to her science teaching?

Does a multi-model approach to teaching produce the kinds of thinking that is creative, flexible, analytic, and synthetic? According to Gardner (2008) and others, this is the kind of thinking that will be needed in the future. We will need adults who can think from 30,000 feet, synthesize large concepts, and bring practical, scalable solutions down to ground level. Does this approach to teaching facilitate that ability to see the grand view and then find local solutions?

In addition to creative thinkers with intact imaginations, Gardner posits, we need citizens who have a moral compass—that is, the ability to think of the greater good. Can we continue to develop curricula that allow children to probe and discuss the great philosophical questions of humanity in order to find empathic and compassionate responses to world situations?

[W]e need citizens who have a moral compass—that is, the ability to think of the greater good.

Predicating this article is the underlying assumption that we want our nation's children to be deep thinkers capable of making connections and creating new thought patterns for the future. Gardner has presented a theory to address these issues, and this article posits that Waldorf education is a method of teaching that long ago embraced Gardner's theory of teaching for understanding. Confirming the view that using the entry points theorized by Gardner and practiced by Waldorf educators leads to a deeper, more connected way of understanding a topic will bolster an argument for applying the findings to public school classrooms where most of the nation's children are being educated. This would directly challenge the narrowing of the curriculum that is currently occurring in American public schools as an unintended consequence of the focus on high-stakes standardized testing (Ravitch 2010).

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Extending the Arc

A Direction for Waldorf Education in the 21st Century

Han Safit

This paper is based on a talk given to the faculty at Green Meadow Waldorf School, Spring 2017.

It was suggested to me to talk about the future of Waldorf education in the 21st century, a suggestion I immediately accepted, simply because it makes so much sense.

The question makes sense because education, and especially Waldorf education, is by definition *future oriented*. This is one of the things that makes Waldorf education unique and right: that the practice itself, the class time, the face time, the time of co-presence of child and teacher is, on the one hand, fully grounded in the here and now—in the face-to-face contact, in the removal of distractions, and in the living in the present, in this very moment, of this story, this image, this bread loaf, this body movement, this number, this idea—while originating from the past, sometimes from a very ancient past. And yet, the whole situation, the whole work done in the school is projected toward the future: the future person and future life of this child who is in my classroom today.

As Waldorf teachers, you all know that the mission of your work, whether conducted between four walls or out in the garden, is that of assisting these children into their futures—not necessarily into their future *careers* but into the future person each will become. You know that you are gardeners who do not have the ability to enter the seed and make it become a plant, a tree, a flower, or a fruit, but that you can and you do provide these seedlings with the nurturing, and guidance, and support, and tools to flourish in this world as they will take off onto their own individual paths.

About these paths: Where do they lead? What becomes of your students when they graduate from Green Meadow? What becomes of Waldorf students in general when they complete the course of their primary and secondary education and go out into the world? Where are they, who are they, and what are they doing beyond the college years? Do we know? Do we have a clear picture?

One of the great things about the insider's view in a Waldorf school is the visual unfolding of a developmental arc, an arc that stretches from nursery to 12th grade and through which the development of a child into an adolescent becomes clear. One of the great things about a well-integrated and well-functioning Waldorf school is that the 12th grade art teacher, for example, can compare notes and images with the former class teacher of her or his students and visualize the progressive arc that leads from a child's second grade drawing to her 12th grade self-portrait. In placing side by side a set of drawings, produced along an extended period of time, the development of this child becomes visible, just as it does when placing side by side a collection of main lesson books, from first grade through twelfth grade. This is one way of making visible the particular arc of development of an individual child within the guidelines of the Waldorf curriculum, just as the arc of development of the Waldorf curriculum itself is visible in its general outlines to each informed and experienced Waldorf teacher.

But I think we now need to extend this arc, which means to have, indeed, a clearer picture of what has become of the Waldorf child after she has left the school, gone into the world, experienced college, made some life choices, and is now 35 or

47 or 62. Where is she now? What is she doing? How did the guidance in her childhood years set up the course of her later experiences?

I have asked this question at several different Waldorf schools, and I did get answers: They are artists and artisans, and teachers and social workers, dieticians and biologists, designers and architects. Whatever they are doing, it seems to me that their work is invested in the well-being of people or in the spaces in which people live, study, or work. But this is an impression, my impression, based on scattered questions here and there, and I think what we are missing, what is very much needed, is a clearer picture of the future of the children that Waldorf schools have sent into the world.

About this world and the world's future: It seems very clear to me—and I would certainly not be the first one to suggest this—that the future of this world, a future which is already upon us, is framed by two life-altering factors: ecological disruption and the ubiquity of technology. These two factors are altering and will continue to alter human experience, human existence, and the world where this existence takes place, a world-existence that is inextricable from human-existence. How does this relate to the future of Waldorf education? Very deeply.

Let's start with technology. Waldorf education, as you all know, has had a difficult relationship with modern technology, especially in recent years with the rise to what almost seems like absolute dominance of screen technology, and especially the hand-held screens that dupe people into thinking that they are holding the world in their hand, that everything is instantly knowable and everywhere is immediately reachable. We become more and more distracted from our surrounding world, from the here and now, from the capacity of sustained attention, from the ability to follow a prolonged line of thinking, from the inner power of a self-controlled will.

And yet, we need to remember, and we will eventually need to find ways to instruct our students, that the history of human incarnation, that is, the history of civilization, of carving a place for ourselves in the physical world—which is still the world we navigate best—is inseparable from the history of technology. From the stone, to the flint, to the stick, to the fire, to the wheel, to the spear, to the tent and the hut and the plow and the lyre and the flute and the pen and the keyboard to the screen—these are all modes of expansion of humanity into the physical world made possible by the tools of technology. What man is in his inner core is one thing: What he has become in the here and the now of physical life was made possible by these tools, by technology. And this incarnation into the physical world goes beyond survival and sustenance and economy: Technology enables art, writing, self-expression, creativity. Technology can no longer be perceived as that which is opposite and opposed to human nature.

What I am trying to say is that Waldorf education needs to reassess its relationship with technology. It needs, in my view, to spend some good, thoughtful time with this question, which for quite a long time was dealt with in a reactionary way in order to keep away the clear harms of unchecked screen technology. We need to invest ourselves in a better understanding of the role

of technology in human development and the current human being, so we can go back to the classroom and nurture a healthy understanding in the student, an understanding that will translate into an ability: the students' ability to discern when they are using technological tools and when they themselves are being used by technology; when they are assisted in their perceiving and thinking by machines, and when they are handing over their thinking to machines to do the job for them, to *be* instead of them.

A better understanding of the role of technology in human existence is also crucial

Waldorf education needs to reassess its relationship with technology.

for the other dominating factor in the unfolding future, what I refer to as ecological disruption. You can also call this the environmental crisis: the tilting out of balance of various systems of nature, leading to or manifesting in pollution of air, water, and soil, rising levels of carbon in the atmosphere, rapid extinctions of various species, the melting of ice caps and ice plates, the consequential rise in sea level and flooding of low lands, etc. This is all very troubling to lovers of nature and environmentalists, but environmental issues should concern *everyone* because they are about to change *everything*. For example, the rising of sea levels will force mass human displacement. Bangladesh alone—a nation currently counting 161 million souls—is predicted to be underwater by the end of the century. Where will all these people go? Can you imagine the effects of such displacement? Surely their neighbors in India, a nation of already 1.3 billion people, millions of whom are living at unacceptable levels of poverty, will welcome these environmental refugees with open arms and readily available resources? Probably not.

In general, the unsustainable rise in human population and the justifiable but even less sustainable rise or demand for a rise in standards of living in developing countries, coupled with the fast decline in non-renewable energy resources make it very clear that these so-called environmental problems portray a future that will challenge and even endanger various aspects of human and non-human life. The problems that we call *environmental* already prove to be *existential*.

Now that I've managed to scare you, let us go back to my previous question: How does this relate to the future of Waldorf education?

Well, the futures of Waldorf and of Waldorf graduates are going to meet the environmental-existential challenges of the future picture to which I have alluded. This is their future. If this future, wherein the climate has changed and the conditions of living have transformed, is

a real and clear possibility, isn't it the role of educators, whose entire work is projected toward the future, to either prepare for or perhaps even alter such a future? Furthermore, isn't Waldorf education, with its cultivation of respect and love for nature, with its emphasis on our dependence on and gratitude for the world of nature, and with its fundamental commitment to ethical responsibility—so fundamental we don't even say it—isn't Waldorf already geared toward preparing Earth's protectors? Didn't you already release into the world a great number of environmentalists?

The future needs help, and Waldorf education, with its intrinsic ecological and ethical grounding and outlook, is well-positioned to take part in, perhaps even to take a *lead* in this help.

In presenting his newly-formed educational approach to the audiences that cared to listen, Rudolf Steiner often designated its mission as preparing a generation for its future task. The task at that time was to reconstruct Germany's social and moral landscape after the devastations of the Great War. Ironically, Steiner, despite his far-reaching clear vision, did not see into the future and the even greater devastation that the next Great War would bring. Today, we do not need clairvoyance to see what the future would be like if the trends of ecological disruption continue in their current direction. Climate science, along with other scientific fields, tells us quite clearly what the ecological future will be, and how it will be setting the physical conditions of a social future. With such a future in mind, we are called upon to renew the original impulse of Steiner's Waldorf education as a cultivation of the next generation for its future task.

This means in practice that as we gain a better picture of the current future of former Waldorf students, namely what and who they have become, we might be able to direct future Waldorf graduates more explicitly and more pointedly to their place in a future that needs them. In recent years, more and more professions and tracks of higher education have been developed and continue to develop with

the aim of addressing the looming environmental crisis and adjusting to more sustainable living. These include various fields of science—climate science, earth science, oceanology, ecology—and proceed to engineering, sustainable agriculture, design, and architecture; green economics and environmental education; journalism and philosophy; and further to environmental policy, politics, and smart technology. These are only some of the directions and professions that already await Waldorf graduates and that will allow them to both fulfill themselves individually and direct themselves collectively to the greatest challenge ever to face collective humanity.

Generations X, Y, and perhaps even Z have been characterized by the apathy, disinterest, and the self-centeredness of their ways—a characterization that is often attributed to the lack of a major, heroic, existential challenge, like the one that faced the Great Generation in fighting fascism and reconstructing a post-war world. If this is the case, then *this* generation and the ones that will follow has finally found its challenge and calling before it even knew that it was looking for one. You can call it generation E, for Ecology, a subject that perhaps needs to be introduced as a main lesson in Waldorf high schools in order to clinch and reinforce the values and worldview the students have already been encouraged to develop in previous years, and in order to guide them in the direction of these multiple professions and various individual paths, that all lead in one direction.

An ecological outlook, in my view, is already at the core of the Waldorf approach, one that looks for and finds the relations and connections of all things, organic and inorganic, that make for the web of life and culture, and that include the viewer who is not a mere outsider to this view. Waldorf education directs its students to look into the world with sympathy. *Sympathy*, from the Greek *sun pathos*, “with feeling,” means to look into the world with the emotion that binds us internally with the world externally. Emotion, as you know, is an internal thing: If you find

yourself crying while watching a movie, it is not because the character is hurting; it is because *you* are hurting for the character. In other words, it does not testify to the emotion you are exposed to externally, but to the emotion you are experiencing internally. To look into the world with sympathy means, from the outset, to foster our internal bond with a world that only appears to be external to us, to cultivate the approach that makes it clear that we are *of* the world and the world is of ourselves.

This is one of the senses in which Waldorf education is already imbued with an ecological worldview, with which we prepare our students to step into the world and find in it their individual paths.

An understanding of our relationship with technology will be necessary in any of these paths—because just as we would not have been able to disrupt the ecological balance without all the technological equipment and the unguided and thoughtless ways in which we have been using it, so it will not be possible to correct this imbalance without technology and a thoughtful, guided use of it.

How do I see the future of Waldorf education in the 21st century? I see it proceeding by understanding what kind of future past Waldorf students have developed, rethinking the question of technology and incorporating this new understanding into the high school curriculum, and devising more explicit ways for directing future Waldorf graduates to align their personal futures of self-realization and self-fulfillment with the collective task of ensuring a livable future for all in an ecologically balanced world.

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Report from the Online Waldorf Library

Marianne Alsop

The Online Waldorf Library continues to be a popular and helpful site for information about Waldorf education, with nearly 120,000 site visitors since January 2017. The United States, Australia, the United Kingdom, India, Canada, Mexico, Philippines, Spain, South Africa, and Malaysia round out the top ten countries for site visits. Visits from New Zealand, Argentina, Chile, China, and Brazil have significantly increased over the past months, and Singapore has appeared for the first time! It is exciting to see where Waldorf education is growing and where the OWL is meeting the need for freely accessible information.

It is interesting to note that the most downloaded eBook on the OWL is *25 Plays*, David Mitchell, editor, with 24,370 downloads since 2015.

Since the spring of 2017, we have added a number of new eBooks in Spanish and one in English. Spanish eBooks include: *Geron y Virtus*, *Columbano*, *El Libro de las Abejas*, and *Abejita Rayo de Sol*—all by Jakob Streit; *Hablemos, Juguemos: Ayudar a los niños a aprender de la vida* by Jane Winslow Eliot; *El arte y la ciencia en la enseñanza de redacción* by Dorit Winter; and *Hijos de cíclopes: La influencia de ver la televisión en el cerebro humano en desarrollo* by Keith Buzzell. A new eBook in English is the new edition of *Nøkken* by Helle Heckmann. To our collection of audio books we have added *Clothing the Play* by Roswitha Spence.

A number of new articles in English have been added in preparation for the world-wide Conferences on the Importance of Sleep, initiated by IASWECE (International Association for Steiner/Waldorf Early Childhood Education). In

addition, fourteen new articles in Spanish have been added and can be found via the home page tab, Artículos en Español.

As always, back issues of the *Research Bulletin*, *Gateways* (Waldorf Early Childhood Association), *Pedagogical Section/Rundbrief* and a number of other international publications are available online in our Journals section.

The Online Waldorf Library welcomes your questions, and we are happy to help you with your research projects.

www.waldorflibrary.org



Patrice Maynard

The season behind us saw further preparatory work on a new “Survey of Waldorf Graduates” from Waldorf high schools across North America. In the season ahead, Connie Stokes takes up the challenging task of collecting names and email addresses of high school graduates. This work will require the help of our Waldorf high schools to ensure the success of this worthy research project. Results of the survey—which will focus on the last 25 years of graduates from some 40 Waldorf high schools in the U.S. and Canada—are expected to be published in 2019, coinciding with the “Waldorf 100” celebration of a century of Waldorf education. The results will include responses from college and university professors, employers of our graduates, and the graduates themselves. Douglas Gerwin, RIWE Executive Director, is working closely with Connie to develop the research protocols for maximum return on the research efforts.

As Waldorf 100 comes closer, schools across North America are participating in varied ways. Waldorf school faculties are undertaking the study of Rudolf Steiner’s seminal lectures to the first faculty members in the Stuttgart school, *Study of Man* (or *Foundations of Human Experience*). The Pedagogical Section in Dornach has asked that Waldorf schools around the world (now over a thousand strong) to take up a new study of these lectures as a coalescing and imaginative effort to unite around the celebration of 100 years of Waldorf education. The Research Institute, in collaboration with the Pedagogical Section Council of North America, and using Waldorf Publications for production and design, has published *Entry Points: A Guide to Rudolf Steiner’s Study of Man*. An introductory manuscript has already been sent to schools to

assist in their studies for the first five lectures of the 14 Steiner gave. The entire book is likely to be ready for publication in 2018.

Helping Children on Their Way: Educational Support for the Classroom—edited, illustrated, and in part written by Elizabeth Auer—has been given a silver medal Mom’s Choice Award. This is an award which reaches beyond the Waldorf circle into mainstream recognition. This honor underscores the universal value of this collection of essays by experienced educators from North America and Europe. The book includes instruction on many of the tools we have as Waldorf teachers and parents to approach solving the mystery of each child effectively. Especially useful for newer teachers who might not know what to do when a child is struggling in a class filled with lively little ones, the book provides many ideas for all teachers and parents to push beyond the mainstream imagination of “remediation” and into the ideas Rudolf Steiner outlined for the first teachers.

Find the Research Institute for Waldorf Education on Facebook. We are just shy of 50,000 friends—join us!

Acknowledgments



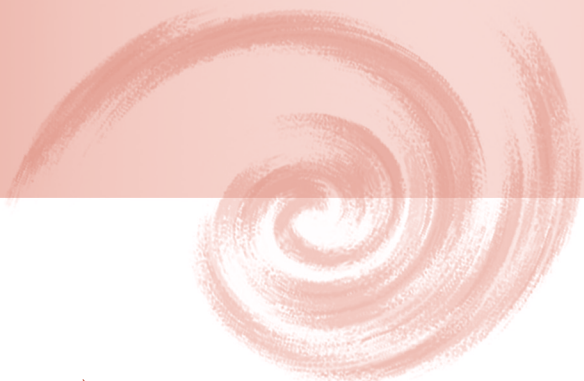
It is with deep gratitude that the Research Institute for Waldorf Education and Waldorf Publications list the donors who have made our work in 2016-2017 possible. The recognition of

the importance of our efforts, arriving from our supporters through gifts, lifts us at least as much as the generosity of the financial contributions made. Thank you!

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About the Research Institute for Waldorf Education

The Research Institute for Waldorf Education (RIWE), founded in 1996 in order to deepen and enhance the quality of Waldorf education, engages in sustained dialogue with the wider educational-cultural community and supports research to serve a wide range of educators in their work with children and adolescents.

The Research Institute supports projects dealing with essential contemporary educational issues such as computers and the effects of media on children, alternatives to standardized testing, physical health and psychological well-being of students, science teaching with a phenomenological approach, the role of the arts in education, and the philosophical underpinnings of Waldorf education.

As a sponsor of colloquia and conferences, the Research Institute brings together educators, psychologists, physicians, and social scientists for discussions on current issues related to education. RIWE publishes a *Research Bulletin* twice a year and prepares educational resources, including collections of eBooks and articles (a growing number of them newly translated into Spanish). Many of these publications are available without charge on the website of the Online Waldorf Library (OWL), a virtual library created and managed by the Research Institute: www.waldorflibrary.org.

In 2013 the Research Institute took over the publications arm of the Association of Waldorf Schools of North America (AWSNA) and re-branded it as Waldorf Publications. It includes resources for teachers and administrators, readers and children's books, collections of plays and poetry, science materials and kits, science and math newsletters, inspirational essays, proceedings of colloquia, and a range of publicity materials about Waldorf education. It also carries

books published by the Waldorf Early Childhood Association of North America (WECAN) and the Pedagogical Section Council (PSC) of the School for Spiritual Science, as well as AWSNA's twice-yearly magazine *Renewal*.

As an initiative working on behalf of the Waldorf movement, the Research Institute receives support and guidance from the PSC and financial support through the following organizations:

- Astoria-Stiftung
- Foundation for Rudolf Steiner Books
- Freunde der Erziehungskunst
- Marshall and Margharite McComb Foundation
- Rudolf and Clara Kreutzer-Stiftung
- Rudolf Steiner Charitable Trust
- Sprout Foundation
- Waldorf Curriculum Fund
- Waldorf Educational Foundation
- Waldorf Schools Fund
- Waldorf-Stiftung

The Research Institute is a tax-exempt organization and accepts contributions through its annual giving campaign and special appeals.

Summary of Activities Supported by the Research Institute

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A think tank for questions of freedom in education

COLLOQUIA (with published proceedings) on teaching:

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World History: Symptomatology

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Alternatives to Standardized Assessment
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Survey of Waldorf Graduates
Waldorf High School Curriculum Research Projects

RESEARCH BULLETIN

Two issues per year of essays, articles, reviews, and commentaries on educational themes

RETREATS OF THE RESEARCH INSTITUTE

Presentations and discussions exploring contemporary questions related to education

RIWE WEBSITE

Collections of articles and news features on current educational issues

TEACHING SENSIBLE SCIENCE

Three one-week courses on teaching science in elementary grades using a phenomenological approach

WALDORF PUBLICATIONS

Over 400 book titles, plus science kits, publicity materials on Waldorf education

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