

A large, textured blue spiral graphic that starts from the center and expands outwards, filling the left half of the cover. It has a hand-drawn, chalk-like appearance.

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A smaller version of the blue spiral graphic, located behind the text of the Research Institute for Waldorf Education.

Waldorf
EDUCATION

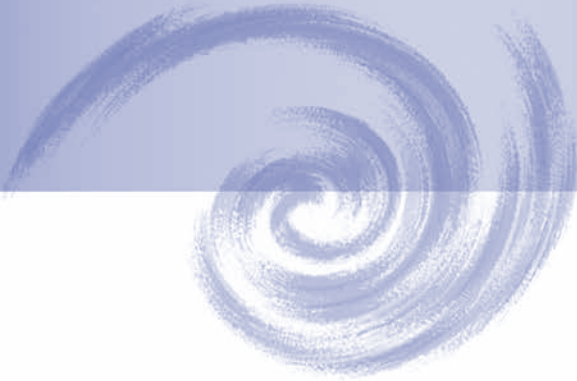


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John Wulsin

Waldorf high school teachers want their students to meet, engage, understand the technology of their times, in ways that enable them to meet technology of the future healthily as well. On the other hand, we're acutely aware, at the actual dawning of their increasingly individualized thinking, how crucial simply writing by hand in ninth and tenth grades can still be in increasingly individualizing those burgeoning capacities for thinking. We have a graduate who was instrumental in managing the robot landing on Mars, one who is at the cutting edge of computer/human interface in various kinds of handicaps, physical and otherwise, one who already as a high school senior was hosting a weekly radio program, advising businesses and institutions about strategies for coping with hackers. Many Waldorf graduates excel at both computer programming and creating websites for a whole range of needs, combining technical and artistic capacities and the ability to recognize the essential nature of any particular enterprise.

Generally, it may be fair to say that Waldorf students, having not been formed by technological influences in their childhood, are free to *inform* the technologies they later work with, exercising flexible ways of thinking and with the ability to sustain large, unifying imaginations. In their formative years, Waldorf students have not been programmed to operate like computers. Therefore they are free to work in technology, with it without being "of" it.

In conjunction with its annual board meeting in April, the Research Institute held its third weekend colloquium, this one jointly with the Pedagogical Section Council on the theme of technology in education. During the course of two days, Arthur Zajonc and Jason Yates made

presentations based on their research in the fields of computer programming and quantum physics. As a result of this weekend retreat, a range of articles has been gathered for the *Research Bulletin*, as well as for a collection of essays prepared by Waldorf Publications on this current "hot topic."

Dr. Michaela Glöckler, in our keynote article, sets the stage for our explorations by both celebrating the fortunate timing of contemporary technology for humanity at large, and calling for us to awaken to the crucial questions of appropriate timing for the effects of technology in relation to the healthy growth of each individual, especially in childhood.

Michael Holdrege, long-time Waldorf high school science teacher, illuminates and elaborates many of the distinctive forms, capacities, and qualities of the most essential element in our contemporary technology, silica. Gopi Krishna Vijaya offers a first installment, from a contemporary perspective, of historical contexts of streams of human thought leading toward current technology. Jason Yates, both computer technician and eurythmist, offers a first installment of his endeavors to articulate the essential gesture of our digital world.

George Russell, emeritus professor of biology at Adelphi University and former editor-in-chief of *Orion* magazine, has edited a collection of articles in *Children and Nature*. Here he shares reflections on children's relationships to both nature and technology.

Lowell Monke, long-time teacher of computer science to adolescents and Professor of Education at Wittenberg University, shares grounded perspectives on appropriate timing of technology education for growing youth.

Patrice Maynard, former class teacher and current director of Waldorf Publications, offers insights on technology from within the experience of Waldorf schools.

In one of three reports, Amalia Pretel-Gray shares her journey as a language-oriented class teacher, experiencing gradual and even dramatic transformations catalyzed through training in “Teaching Sensible Science.” Marianne Alsop, of the Online Waldorf Library, reports on recent Spanish and Mandarin translations, accessible of course throughout the world. Recent Early Childhood additions range from *Seeking Sourdough* to *Seeking the Spirit*. The first audio books have been added to the Library, including both assessment and physics. Patrice Maynard reports on recent Waldorf Publications, which range from new research on Waldorf graduates to Lakota stories from the classroom at the Pine Ridge Reservation in South Dakota, from medical insights to extra help for children.

In the wake of Tertia Gale’s illness and recent death, the board of the *Research Bulletin* asked me to serve as temporary guest editor, to relieve Elan of his duties for this issue. It turns out that the Tertia many of us knew, with all her various rich dimensions, had also served as

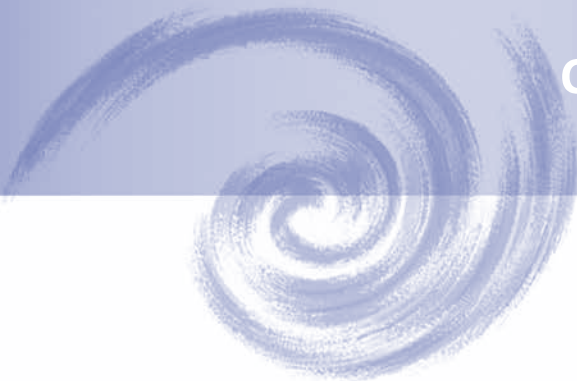
keen, hawk-eyed proofreader/copy editor for the *Research Bulletin* for many years, assuring a fine, professional level of clarity and correctness. We are grateful for the devoted keenness of her attentions to this journal’s work.

As a long-time Waldorf high school English teacher, I certainly feel little authority to legitimately introduce this particular issue, focusing primarily on technology. But as a career-long “editor-in-the-trenches,” I feel fully the right to declare that I am deeply impressed with the quality of perspectives of these articles; I feel it a privilege to host their offering to our readers.

The *Research Bulletin* has received, in fact, such a wealth of fine articles exploring technology that we have decided to continue to broaden and deepen our understanding with further articles on technology in the spring issue.

May these articles, with their outstanding historical perspectives, their scientific, mathematical, philosophical, and educational savvy, and their deep understanding of human nature, help us all neither to fear technology nor to be seduced by it, but rather to become increasingly able to use it to further fulfill our humanity.

Authors who wish to have articles considered for publication in the *Research Bulletin* should submit them directly to the Editor at: waldorfresearchbulletin@gmail.com.



Challenges in Our Relationship to Technology

Michaela Glöckler

On several occasions, Rudolf Steiner made bold, prophetic predictions about what life would look like in the coming one to four years, also concerning technology.¹ It is striking how precisely he formulated these predictions and how accurate they have been so far. Steiner was able to read the signs of the time and could therefore develop a prophetic vision. This article is devoted to the following questions:

1. *What perspectives open up when we consider the development of technology?*
2. *What would an adequate way to deal with technology look like?*
3. *What can we do in order to influence cultural development and steer it in a positive direction?*
4. *What consequences will information technology have for the healthy development of children and adolescents?*

1. Rudolf Steiner on technological progress

Technology bringing death – one aspect

Rudolf Steiner spoke enthusiastically out of his spiritual-scientific research about the being of technology.² Contemporaries report how he once rode in his car through the Ruhr region, then the largest industrial area of Germany, and said, looking out of the window, “All dead.” For him this was a simple statement of fact, not a lament. In his lectures he explained further how technology would bring death for the earth because it uses up our energy reserves and brings in its wake both destruction and profound upheaval.³ Not only is technology dead in itself; it also has the effect of bringing death. Our steel industry is not only responsible for many

“peaceful” machines and cutting tools; it also has global ties to the production of weapons, which bring death, to say nothing of the use of atomic energy for both peaceful and destructive ends. A responsible, environmentally conscious use of technology, therefore, presupposes a highly developed morality.

Technology setting us free – a second aspect

If modern technology carries within it a kernel of death, which is intrinsic to it, was this why modern technology made its appearance? Surely modern technology did not appear in order to show people the dramatic spectacle of the machine and industry. There was a fundamentally different reason why modern technology appeared in the course of time. And yes, technology appeared exactly because it does have this death-bringing character. Human beings need to develop the consciousness soul, and they can do so only within a dead, mechanical culture, because it provides the resistance necessary to bring that development about. [...] Detached consciousness and the force which brings death are closely related.⁴

Death processes give us the possibility to free ourselves from the material world and thereby detach ourselves from our ties to matter. However, on this gradual path to freedom, the following questions arise:

What should we do with our freedom, and what can we do?

Let us begin by bringing a few basic historical viewpoints to mind. The origins of natural science lie in the 15th and 16th centuries, which gave

*Translated by Jan-Kees Saltet

rise to increasing industrialization in the 17th and 18th centuries. Machines which take physical labor away from human beings were the first to come into existence, for example the mechanical loom. As a result, many people lost their jobs. That was the shadow side of the development. The positive side of this development, then and now, is that human beings are liberated from the drudgery of physical labor. In its wake came the development of measuring techniques and information technology. What was taken away by these great revolutions was work that involves muscles, senses, and feelings (e.g., measuring temperature), as well as spiritual routine.

On the one hand, so-called joblessness creates widespread want. But it also has the effect that millions of people are set free to do what they want all day long. Joblessness opens up the opportunity to seek out freely chosen assignments. If, however, people are merely educated to become wage earners, they won't quite know what to do with the freedom at their disposal and will be "job-less" in the truest sense of the word, facing questions such as:

What do I do with my freedom? What sense does my life have, apart from work?

Which brings us to the next question:

Can one educate people to become entrepreneurial in the way they handle their freedom?

2. Education toward freedom – but how?

In the 1990s the specter of a "20/80 society" was evoked for the near future, a prognosis made by great economic visionaries, backed up by specific numbers and facts. It predicted that, if trends continue the way they have, only 20% of the population would give and have work in

the future. In this scenario the entertainment industry will be the most important carrier of culture. In ancient Rome, those in power adhered to the principle that the populace needed to be occupied with "bread and plays," in order to "keep them quiet." Make sure people have enough to eat and are entertained, otherwise it gets dangerous for society. And indeed, social development around the globe is actually going in this direction. Each individual will be living a great

deal more independently than was possible until now.

So what should our educational plans and our institutions do to awaken an appetite for a creative use of freedom?

Joblessness now looms large; it is a theme relevant

for all of society. Again and again, researchers point out the danger of sliding into addictions and petty theft, if not criminality. The latter are signs of a gradual process of dehumanization, which is a side effect of economic development. There is far too little awareness of the fact that this development has the potential to create unhappiness for up to 80% of society. Therefore the most important questions for the future are:

What can be done for the people in this 80% category? What parallel developments are needed to offer them a different perspective? How do we open the eyes of politicians and civic leaders so that they will steer these developmental processes more consciously and more responsibly?

And what can we contribute to this? A core goal of Waldorf pedagogy is to educate children toward both freedom and social responsibility.⁵ In the future we will understand more and more why that is so important. Education toward freedom has to go hand-in-hand with media literacy.⁶ Technology creates conditions for us to develop freedom, and freedom is a

cultural treasure of humanity. With this premise, technological advances will serve human development only if they are accompanied by an education which takes the signs of the times seriously and prepares children for the world of tomorrow.

Moral implications

This leaves unanswered for the moment the question of what we should do with our freedom, nor have we answered the question of what we actually *can* do. And it brings us to the next one: *Out of which particular spiritual orientation should we act?* Probing further, we come to the question of doing the good, and that implies morality and responsibility. Steiner defines morality as interest in others.⁷ That means: We become more moral to the extent that we are able to develop more interest in other people, nature, or the world, and thereby develop a truer understanding of interconnections and phenomena, big and small.

In the children's service of the Christian Community, we can hear the following sentences. "We learn so that we may understand the world. We learn so that we may work in the world. The love of human beings, one to another, enlivens all the work of Man. Without love, human life becomes desolate and empty. Christ is the teacher of the love of Man."⁸

These words could serve also as a kind of manifesto for the concept of *salutogenesis* (the process of healing, recovery, and repair). The American medical sociologist Aaron Antonovski proclaims that human beings will increase in health when they have the feeling they understand something, can digest things in a meaningful way, and are able to sustain what is important to them. The words he uses are: understandability, meaningfulness, and manageability. Others call this *resilience*.

Human beings need to develop the consciousness soul, and they can only do so within a dead, mechanical culture, because it provides the resistance necessary to bring that development about.

3. Possibilities to influence human development in a positive way

The big question is:

What more can I do as an individual, within the means at my disposal, to step up my efforts to have a positive influence on human cultural developments in the coming decades?

Visions of computer and speech programs

To start off with, here is what Steiner said as early as 1913: "We haven't yet come to the point where schools have stopped teaching religious traditions, but we can't fail to hear the increasing demand for a curriculum which confines itself to natural science."

Germany is one of the few countries that still teaches religion in school. In North America this is just as much of a taboo as it is in Northern Europe, where all that's left is the teaching of ethics. Steiner's prediction has thus been fulfilled to a large extent.

For external life, the demands of these people will become so strong that humanity will become utterly focused on outer things in a very short span of time. People still learn to write today. In a not so distant future, people will only remember that human beings were writing in previous centuries. A form of mechanical stenography will be there, and it will be machine-written at that.⁹

Steiner foresaw the computer and how it would have possibilities to complete words or sentences, the way one now only has to say the beginning of a word and immediately a text box appears with three or four choices—one click and the right word is there. Speech recognition programs are improved by the day. In another lecture Steiner points out how one will be able to "move a ball of cotton from Liverpool to Rome." In this context he repeatedly uses the word *schieben* (move/push), the way we

move electronic data around with a click or a push. He had quite a clear picture of what this “mechanization of life” would look like.¹⁰

We must become clear about ourselves.

Steiner urges us to engage in a parallel development running side by side with the developments in technology, a complementary endeavor which can help us succeed in putting our freedom to good use.

Outer life will be externalized to an extreme degree, but inner life will claim its rights. What we practice today as spiritual science may still be spurned by some people, but there’s no stopping the inner clamoring for the spiritual worlds, which will force materialists into retreat, and people will begin to recognize the Christ. This will take place in epochs which will have an open eye to spirituality, even though this openness will be due to a reaction against the externalization of life.¹¹

In the development of technology, Steiner sees the possibility of waking up to the necessity of going through the outer surface to penetrate into the depths of our being, where we can recognize the Christ as an innermost evolutionary factor. People’s longing will tend toward getting away from the extreme of externality in order to attain the opposite inwardly. To a large extent, this will be a question of education and self-education.

Education toward freedom is not only education toward competence in handling media, the latest games, or mastering the digital world. Education toward freedom also means education toward spirituality.¹² The point is not to “prepare” young people for political or denominational choices, but to enable them to find spirituality by themselves. They need to be prepared to find whatever form fits them and matches their humanity. This is the reason why Steiner used the word *anthroposophy* for his spiritual science. Not the easiest of words, it is of Greek

origin, but in essence it says: True knowledge about being human is there. We can develop a consciousness of our own humanity. It is about building up this consciousness, about becoming clear who we are. Therefore the noblest realm of anthroposophy constitutes the study of the human being, no matter whether one chooses the medical or pedagogical approach or goes at it from an evolutionary point of view.

4. Anthroposophical study of the human being: What does it give us and where does it take us?

How growth forces metamorphose into thinking, feeling, and willing activity

Steiner’s fundamental discovery, his salutogenetic paradigm, shows us a metamorphosis. There are forces which make incarnation possible and give life and form to the body as we grow and develop, and it is these very forces that help us develop in soul and spirit. Just as the body is not formed solely by physical and natural forces, but reveals the workings of life, soul, and spirit, so there are four comprehensive systems which obey archetypal laws. Steiner calls them:

- Physical body
- Ether body/life
- Astral body/soul
- Ego organization/individual human spirit

These forces which are at work in the ether body are active at the beginning of human earthly life—most clearly in the embryo—as growth forces. In the course of a human life a portion of these forces emancipates itself. Instead of being active in forming the body, they become forces for thinking, the very forces which bring forth the world of thoughts, a world which appears shadowy to ordinary consciousness. It is of the utmost importance to know that the ordinary forces of thinking are a finer form of the growth

...[T]he ordinary forces of thinking are a finer form of the growth forces that shape the human being.

forces that shape the human being. The way the human organism takes shape and grows reveals something spiritual. For this then subsequently appears in the course of life as spiritual power of thinking.¹³

Accordingly, the differentiated forces of the astral body show themselves in the course of development as a body-free feeling life. The integrating forces of the ego organization, which are responsible for the overall shaping of a human life, show themselves in that they enable the will to unfold free from the body. Steiner's thesis goes as follows: The forces which build the body, once they have fully formed an organ, are able to leave the body again and also transcend the death of the physical body, living on as "eternal human spirits."

When the human being is fully formed, the forces of regeneration begin to slacken in due course, which brings about the process of aging. Thus these forces can also be seen as leaving the body and giving rise to the riper life of thinking and feeling of older people, provided one guides these freed-up forces into their proper channels of learning and acquiring self-knowledge.

Now the place where this process of becoming free from natural bodily functions occurs is the heart. For the heart is the only place where it is physiologically possible that the enlivening circulation comes to a standstill for a fraction of a second. Here the reversal of direction of the bloodstream occurs at the end of the diastole, in the so-called diastasis (a passing stop). That is to say, the blood entering the heart has to leave the heart again, but in the opposite direction. In between lies a moment when the bloodstream halts and is totally rudderless. This is a "full stop" for the enlivening circulation, in which the ether body is at work. Therefore the ether body can disengage from its work in the body at these moments and, not being tied

At the midpoint of a biography, the life forces come to an equilibrium between working for the spirit, outside the body, and working for the physical, inside the body.

down, metamorphose into body-free thought activity. The brain therefore doesn't produce thoughts, but reflects them. However, the available thoughts have to be made conscious

by means of concrete processes of observation and learning.¹⁴

At the midpoint of a biography, the life forces come to an equilibrium between working for the spirit outside the body and working for the physical inside the body. Due to the decline of regenerative ability, the aging human being then begins to show the typical processes of decline, and individual weak spots appear in the body. A brief indication will suffice.

Growth in childhood and youth

Between birth and death the physical body goes through an interesting development, which I would like to sketch here briefly.

- In the first seven to nine years the sense organs are built up, and the nervous system comes to a basic stage of completion.
- Up to the 16th year the rhythmical functions, that is to say breathing and circulation, gradually come to full fruition.
- The metabolic system and the skeleton need longest to mature and are only fully formed around age 21.

Processes of aging

As we pass the biological midpoint in life, aging begins. Between ages 40 and 50 the first phase of a downward turn takes place, during which the metabolic system and the skeletal system lose vitality. Women enter menopause, experiencing hormonal changes more clearly than men do. First among typical illnesses of this age period are skeletal problems, for example backache, rheumatic complaints, the arm/shoulder syndrome, and metabolic problems such as the onset of diabetes 2 and gallstone colics.

Between ages 50 and 60, there is a further decline of vitality in the lungs, as well as in the heart and the circulatory system. With it come possible dispositions to illnesses in these areas. This is the age when one can expect cases of smokers who are unable to shake their bronchitis, because it becomes chronic. Heightened blood pressure and rhythmic disturbances of the heart begin to occur and can even lead to a first heart attack.

What we see from age 60 on are increased symptoms of degeneration in the sense organs and the central nervous system. The last functions to be affected are the brain and the senses, which decline gradually. An education which promotes health is therefore preventive medicine with an eye to the last third of our lives. Education has the potential to make one fit for old age.¹⁵

From this developmental perspective dying can be seen as the completion of the disengagement of the forces of the different members. They let us live on after death as purely spiritual beings.

Independent activity and learning processes

From the beginning, human development basically obeys the following principle: Self-motivated action leads to self realization. When we are allowed to figure things out by ourselves as children, first through imitation, then through guided learning processes, and finally by setting our own goals, we foster bodily and spiritual development, and this gradual process allows us to become ourselves. Outside interference or indoctrination foster listlessness and fear, setting up blockages and barriers.

So when it comes to dealing with technology and electronic media, the fundamental question arises: At what point in life is access to the media, the Internet or social media a positive

stimulus for development? As long as the child is still growing, one needs to be very cautious, for electronic media have a strong impact. They force one to be reactive; they do not leave one free. Worse still, one-sided, false stimulation gets embedded in the brain and hampers sensory-motor development.

The healthy scenario would be active learning that develops sensory motor intelligence. This

comes about when we can be guided by our own curiosity, when we can learn through our own effort, set our own tempo, and choose the example we want to follow. In doing so we stir body, soul, and spirit. But when we sit in front of a screen, we shut off all our senses except eye, ear, and touch. In addition, we practically shut off motoric activity and lose touch with nature, for the media stimuli have no correlation to living reality and are foreign to the natural origin of our bodies.

Again, the optical and acoustical structures and proportions mediated by the screen bear no correlation to the body and its natural surroundings. This situation has resulted in an ever-increasing number of people no longer feeling at home in their own bodies, for their bodies were not formed through independent activity and therefore don't fit their surroundings. On the contrary, their bodies were formed from the outside, as it were, and now contain impulses that are not rooted in joyful self-determination.

Bodily movement

The study of medicine teaches us that movement is the best stimulus for the nervous system. With brain-damaged children we do gymnastics, baby gymnastics, and curative gymnastics in order to practice appropriate movement and good bodily coordination. The English language coined the words

[W]hen we sit in front of a screen, we shut off all our senses except eye, ear, and touch. [W]e ... shut off motoric activity and lose touch with nature, for the media stimuli have no correlation to living reality and are foreign to the natural origin of our bodies.

“support of embodiment,” and there are “embodiment treatments” that support healthy physical maturation for the many nervous, underdeveloped, and ill-adapted children of our time. Preference is given to movement which the child carries out vigorously. By contrast, sitting in front of a television or computer is exactly the opposite of what is healthy. This is especially important during the first nine years of life, during which time the development of the nervous system and the sense organs stands in the foreground.

Soul activity and inner mobility

During the 15th or 16th year, soul activity and movement come first and foremost for human development. Our bodies bring to fruition the circulatory system: the heart and the organs of breathing. How deeply do the children breathe in? Are their hearts filled with joy or stiff with fear? It depends on the degree to which their souls are engaged.

How is the child's soul set in motion in a healthy way?

This can occur, for example, when a child connects emotionally with what is offered in the lesson. It will happen when the tension varies within one lesson, and students can go from a mood of seriousness to one of total hilarity. All this stimulates the whole spectrum of feelings and the inner mobility and power of expression, which in turn foster the development of rhythmical functions of heart and lungs.

When I was working as a school doctor at the Waldorf school in Witten, a mother once told me how this could be experienced in the school life of a child. She told me how her son came home in fifth grade and enthusiastically kept her abreast of the story of Julius Caesar, each day telling her the latest event that had been recounted in the history block. Then one day he simply threw

his schoolbag in a corner, ran up to his room, slammed the door shut while shouting, “Mom, Caesar is dead!”

The best remedy against computer dependence is when children find life exciting, without the computer, and are not bored, especially not in school. Ideally, computers are technically explained in 10th grade in Waldorf schools and employed in the process of teaching from then on, where appropriate.¹⁶

Mental flexibility and authenticity

What needs to be developed in high school is mental flexibility. One can speak of conscious media mastery only when freedom and mental flexibility begin to become a reality. Jacques

Lusseyran describes in his autobiography, *And Then There Was Light*, how at age 16 he and a friend agreed to tell each other only the truth from then on. The first thing they did after that was to say nothing for long stretches of time. ... Clearly, this

marks a birthday for independent, responsible thinking! From this moment onward, it can begin to develop. I remember a less noble experience at age 15, when I first really became conscious of this kind of inner awakening. This instance happened in ninth grade at the Waldorf school I was attending. There were over 40 students in my class. I looked around the classroom and noticed a boy with whom I had never exchanged a single word—and became very ashamed of myself. We had been together for nine years in the same class, yet I had never spoken with him! I also knew in that moment why not—because I found him a “goofy.” I didn’t even know why. It was based on a prejudice, on outer sympathy, or rather on antipathy. During the break I then went up to him and asked him in Schwabian dialect what subject we had the next period. “Euro,” he said, which was our abbreviation for eurythmy. That was our first dialogue. And I was happy how “normal” it felt.

The best remedy against computer dependence is when children will find life exciting, without the computer, and are not bored...

Self-reflections and actions of this kind are typical for the birth process of freedom in thinking, feeling, and responsible action. By means of thinking one learns to distance oneself from one's feelings and emotions. One is no longer at their mercy, but is happy to learn to look at them, observe them, and control them. With that, one feels freer from them than was the case before, more self-reliant and "authentic."

How the etheric works by day and at night

In the process of thinking, which we owe to our etheric forces having become free from the body, as described above, we are exercising a body-free activity during the day. At night, when we're not thinking, these etheric forces connect with the ones remaining within the organism, and they regenerate especially the nervous system. Then follows a separation of the ether body, i.e., the part that is free from the body by day, away from the combined astral and ego, a separation whereby the latter organization remains active outside the body at night, even though we are not aware of it, except in our dreams. Thereupon pictures and images which were thought and experienced during the day are imprinted into the body each night, where they either support or hinder regeneration, in accordance with the qualities they possess. When we are active during the day and full of enthusiasm and warmth in our thinking, this will bring uplifting, lively aftereffects from our thought life into the nightly regenerative processes taking place in the nervous system. And the bodily functions will likewise benefit from all our positive efforts, since they are tied in with the nervous system. The reverse will have the opposite effect.¹⁷

We need ... [t]he largest possible global outreach through the media, which is today's trend, and [a] maximum amount of deepening of the inner life in order to compensate.

What the Internet and the social media can do to bring our culture forward

We have spoken about inward liberation, self-reliance, and self-governance. Once we have taken steps toward those three ideals—now we can also say: toward authenticity—we have made ourselves available for new tasks.

Our bodies need a lifelong, healthy form of egoism—a strong immune system, that is, so that we can stay fit in body and spirit. However, this doesn't contradict the need to "serve others," a capacity we human beings have as well. This may sound as if we would be in for a process of self-erosion, but it is actually the exact opposite. The more free we feel, and the more capacities we have, the more competent we will be to bear the

sorrows and needs of others and to meet the demands that come toward us from our surroundings. We can become instruments to take on things that are essential to us. In the ideal case, the demands of the world, whether they come as necessity or in the form of questions, pleas, or wishes,

will become synonymous with our own personal wishes. Or, to put it another way: When you have a strong self, you can also let go or renounce without feeling diminished. You can be totally available to do what is being asked. Therefore Steiner says in his book on self-education that the highest form of freedom is to be free from oneself.

When we talk about the place media should have in education, we should always keep in mind what a superb cultural achievement the media are and how useful they can be! Media are highly valuable because of the role they can play in an education toward freedom. I myself use social media enthusiastically, because I see their great potential for networking, and I also value their contribution in civil discourse on social and political questions. Social media facilitate participation and input, and when there are

enough free people, the Internet is a superb instrument to help build social engagement and global consciousness. The media can be addictive, however, and for users who are prone to dependency, they present a lifelong danger.

I haven't been on Facebook all that long yet, only since 2012. I travel a lot, and every time someone tells me we are friends on Facebook, it makes me happy. I like it even though I lost the overview long ago. Likewise, the Aktion ELIANT of the European Alliance of Initiatives of Applied Anthroposophy would not have been possible without the Internet. But I always ask myself what types of content and information are underrepresented on the Internet. There's so much gossip, pornography, and commercialism to be found there, but too little culture as yet...

We need two aspects:

- The largest possible global outreach through the media, which is today's trend; and also
- A maximum amount of deepening of the inner life in order to compensate for this horizontal reaching out.

Both worlds—our spiritual lives and electronics—lie outside the body. Therefore we need a strong spiritual life which is not body-bound, in order to compensate for the harm electronics can do. The etheric body is compromised by the electronic smog, shown both by the fact that people get tired far more easily today and by the penchant to adapt and seek the easy way out. This can be compensated for by a corresponding measure of wakeful meditation.

Our contribution toward a healthy use of technology

There is something which anybody can do straightaway when one wants to use technology responsibly. This goes for technical means in

a general sense, including machines such as an elevator, an escalator, a light switch, or a dishwashing machine. Use them when you need them but remain active wherever that is possible

and sensible. Technology should not tempt us to become lax or soft, because the independent activity which we can do instead of using technology is what keeps us healthy, and we can save energy and electricity at the same time. That way we

won't shun technology; we will become savvy in using it. The point is to stay awake at all times so that we don't get captured by the world of technology.

The point is to stay awake at all times so that we don't get captured by the world of technology.

ENDNOTES

Translation of quotes by JKS, unless otherwise indicated. The most recent American translation of the German titles is given where possible, followed by the original German GA (CW) number and page/chapter numbers in parentheses.

1. See for example: Steiner, R. (2007). *Esoteric lessons*, Rudolf Steiner Press (GA 266 –1, pp. 115–116).
2. See for example: Steiner, R. "The Spiritual Background of the Outer World," title translation by Daniel Hindes, www.rudolfsteinerweb.com (GA 177, lecture 4).
3. Steiner, R. (2010). *Art as seen in the light of mystery wisdom*, Rudolf Steiner Press (GA 275, lecture 1).
4. Steiner, R. (2015). *From symptom to reality in modern history*, Rudolf Steiner Press (GA 185, pp. 67–68).
5. Steiner, R. (1997). *Education as a force for social change*, Anthroposophic Press (GA 296, lecture 3).
6. See also: Glöckler, M. & Göbel, W. (2013). *A guide to child health*, Chapter 27, Children and Multimedia.
7. Steiner, R. (1995). *The spiritual grounds of morality*, Anthroposophic Press (GA 155 , pp. 110–111).
8. From the opening of the Sunday Service for children in the Christian Community, North American translation.
9. Steiner, R. (2006). *Approaching the mystery of Golgotha*, Steiner Books, Anthroposophic Press (*Vorstufen zum mysterium von Golgotha*, GA 152, p. 84).
10. Ibid.
11. Ibid., p. 85.

12. Glöckler, M. & Grün, A. (2008). *Kinder suchen wahrheit – Spiritualität in der erziehung* [Children are looking for truth – Spirituality In education]. Anthrosana.
13. Steiner, R. & Wegman, I. (1983). *Fundamentals of therapy*, Rudolf Steiner Press (GA 27, p. 12).
14. See for example: Fuchs, T. (2012). *Das gehirn – Ein beziehungsorgan* [The brain, an organ which makes connections], Kohlhammer, or: Volbeh, H. (2014). *Was die welt zusammenhält* [What holds the world together]. *Ein grundlegender dialog über materie und geist* [Basic dialogue on matter and spirit] Via Nova.
15. See work cited in note 13.
16. Stoll, C. (2002). *LogOut. Warum computer nichts im klassenzimmer zu suchen haben und andere high-tech ketzereien* [Why computers have no place in the classroom and other high-tech heresies], Klett-Cotta.
17. See work cited in note 13.
18. See under www.eliant.eu.

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Silica: Substance of Earth, Substance of Light

Michael Holdrege

Our daily life creates for us a familiarity with many substances that play a role in our earthly existence. Most people have a feeling for basic qualities of characteristic elements such as silver and gold, iron and aluminum, or compound substances such as carbohydrates and proteins. In some instances, the familiarity is a matter of direct experience, for instance with the metals mentioned above. In others, much of it is in the form of mental pictures or concepts that we have been taught by “the experts.”

In this essay, I would like to explore the characteristics of a substance, silica,¹ that we all have heard about (Silicon Valley is perhaps the most famous valley on earth these days), but we often have little direct awareness of its qualities or the various ways in which this substance manifests in the realms of nature, in the human being, in human creations. In the course of this exploration, we will be looking for characteristic roles that silica plays in the great web of earthly existence. Let us begin with the solid earth beneath our feet.

The Solid Earth

Most people are surprised to learn that 75% of the earth’s solid matter—the crust—is composed of silica. If we break silica² down into its chemical elements, silicon and oxygen, we find, incredibly, that 49.2% of the earth’s crust consists of oxygen and 26.7% silicon.³ This amazing fact is not something our normal experience would tell us. It can awaken the question, however, is there any deep significance to the fact that the solid earth upon which we live and work is three-quarters silica?⁴

If we want to understand the nature of this all-pervasive substance, we will need to investigate the two chemical elements that contribute to its qualities and characteristics: silicon and oxygen. Although silicon and oxygen have “disappeared” into a new and different substance, silica, a significant echo of this heritage is discernible if we take a close look at the characteristics of these two elements.

What are the properties of silicon and oxygen? Silicon is a semi-metal substance (metalloid) that reflects light almost completely



with a dark-silvery metallic luster. It is very brittle and so hard (7 on the Mohs Hardness Scale⁵) that it can be used to cut glass. Silicon requires extreme heat both to melt (2570°F) and to evaporate (4270°F). Surprisingly, despite having a melting point that is higher than most metals,

Silicon is very light, with a density of only 2.34 g/cm³.⁶

Oxygen, by contrast, presents a very different picture. Although everywhere in the atmosphere around us, we can neither smell it nor taste it, and we walk right through it as if it were not there. Almost always in motion, atmospheric oxygen is constantly

heating up and cooling off, absorbing moisture and releasing it. But most important of all in our present context, oxygen is totally invisible. Oxygen’s transparency means it is completely open to the sun’s light, allowing it to shine unhindered from the cosmic heights all the way

Is there any deep significance to the fact that the solid earth upon which we live and work is three-quarters silica?

through to the surface of the earth below.⁷ In stark contrast to silicon, pure oxygen does not want to contract into liquid form, let alone freeze into a solid state. Thus it must be cooled to a temperature below -297°F in order to liquify and below -362°F to become a solid. Ever-present near the earth's surface, its dynamic, life-engendering presence is essential for breathing organisms, and it plays a pivotal role in all processes of combustion (burning), which means it helps transform substances from a solid state into warmth, moisture, and air, with only a small bit of ash left behind.⁸

Remarkably, two such strongly contrasting elements find their way together to produce something totally new, which remains however reminiscent of both. They manifest as silica (SiO_2), which appears in its purest form as crystalline quartz, small pieces of which we know as sand.

Let us experience this remarkable substance in the words of geologist Walther Cloos:⁹

Anyone who has hiked in the mountains, and who has had the good fortune to find a clear crystal in the cleft of a rock, knows the amazement that comes over one when looking at this seemingly unreal creation. Something with the clarity of air, with the transparent purity of a bubbling spring, seems united here with the sternness that reigns in the world of massive rock formations. The dark density of matter, that every stone along the way reveals, seems cast away by a mysterious power that has magically brought forth this crystal out of the bluish-black slate or dense, impenetrable granite.

From another perspective, Fritz Julius observes:¹⁰

More than other substances, silica presents its essence in an image. This image is that of the quartz crystal. ... The substance is hard, impenetrable, and excludes us from its sector of space, but still invites us to enter. ... Along



with light, we may penetrate into every niche and cranny.

Sometimes we encounter an imperfection, a crack, or a small cloud. But these things seem to be there only to enhance the beauty and play with the light. ... The walls are built like the cells of a honeycomb; thus, a six-sided column arises with a pyramid-shaped roof. Gravity had nothing to do with making this form; it is impossible to tell how a crystal was oriented as it grew. ...

When we open such a cavity in a seemingly barren rock to discover sparkling crystals pointing from all sides toward the center, then we see that silica's growth gesture is in all directions. ... It is no wonder that in this transparent substance the most delicate, pure, and transparent colors can appear, especially the violet of amethyst or the ethereal pink of rose quartz. ... Quartz appears to be made from a substance that was created for a never-ending play with light. ...[yet it is] found in cavities deep within the darkness of the earth's crust.

Through these descriptions it becomes apparent that the qualities of silicon and oxygen

have united with one another in quartz (silica). Although quartz is very hard (7) and brittle, as is found in silicon, it has lost the dark, reflective nature of that metalloid. Indeed, it lets the light pass completely through it without resistance. A solid, earthly substance has been created that is open to the sun—thus revealing a primary quality of oxygen. On the other hand, what was oxygen has given up its dynamic mobility in deference to the strongly formative tendencies of silicon.

The largest oxygen reserve on earth (by far) has been fixed in a highly inactive form not only as pure quartz, but also in a multitude of silica-containing rocks known as silicates, which together make up 97% of the earth's crust.¹¹ This amazing substance silica, that unites, one might say, the realms of heaven (oxygen) and earth (silicon), provides the foundation upon which we live.

But silica is at home not only in the solid earth. We also find it playing a significant role in the life of organisms that stand in a direct relationship to the light of the sun: the plants.

Silica and the Plant World

Tapping into the kinship between light forces and silica has been part of the methodology of biodynamic (BD) agriculture for decades. Finely powdered quartz crystals used in the BD preparation Horn Silica (501) work on the above-ground, aerial parts of plants¹² both to reinforce the effects of sunlight and to stimulate photosynthesis.¹³ They strengthen the stem structure, also improving the quality and disease-resistance of leaf surfaces and fruit skins. For plants grown either in greenhouses or under shady conditions, Horn Silica (501) helps compensate for the shortage of direct sunlight that they receive.¹⁴

The horsetails (*Equisetum*) and grasses (*Gramineae*), to take just two examples, show high silica concentrations and share a similar

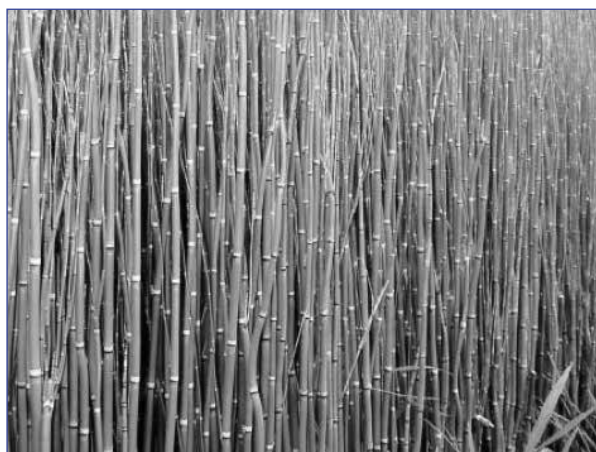
linear, ray-like gesture in their sun-oriented central shoots. Basically just segments of stalks rhythmically spaced and put together, horsetails manifest the principles of form and structure to an extreme. The cone-shaped bodies of the first shoots are made up of tiny, flat, hexagonal scales that develop further into a precise series of linear stem segments pieced neatly together with a brittle rigidity. Interestingly, the fine, silica-based structure of the horsetail's surface solidifies as

opaline glass, whose lenticular bulges bring the sunlight to focus on rows of chlorophyll-containing cells below them.¹⁵

This tendency to linearity continues in the silica-rich grasses.¹⁶ Their strong relationship to the sun shows in the predominance of the central shoot. With long internodes,

the lower part of the leaf shares in the vertical character of the stem, enveloping it as a sheath before the narrow, parallel-veined leaf unfolds to the side. Their sharp, silica-rich, finger-cutting edges are known to many. The grass stem is a master of static engineering, using a minimum of matter to carry its heavy, seed-bearing upper region upward toward the sun. Since their narrow stems and leaves produce minimal, light-hindering shade, they surpass all other plant groups in their ability to take up the light forces of the sun. Whereas the typical light-utilization-level

This amazing substance silica, that unites, one might say, the realms of heaven (oxygen) and earth (silicon), provides the foundation upon which we live.



of non-grasses is between 5 and 10 percent, the grasses are able to increase their light-immersion-level to 24 percent.¹⁷

Grasses in the Sunlight

This sunward-radiating tendency appears, of course, not only in the grasses but in plants in general. In the herbaceous plants, the formation of the central shoot, referred to by Goethe as the “vertical tendency” in the plant, shows in particular a relationship to the sun. In many species the growing tip turns directly toward the sun and follows its movement from morning to evening.¹⁸

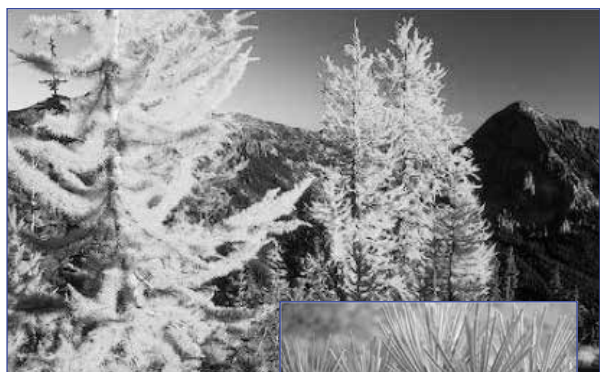
A striking example of silica-mediated qualities in an herbaceous plant appears in the common dandelion (*Taraxicum officinale*). With their high silica content¹⁹ and light sensitivity, dandelion leaves appear in the most varied forms, depending on the time of year, the climate, the elevation, and the type of soil where the plant finds its home. Under shadowy, moist conditions, the leaves widen gradually toward the ends and take on an undivided, elongated form. In an environment with strong sunlight and nutrient-poor, sandy soil, we find denser shoots, smaller, drier, and much more differentiated, sharply chiseled leaves, together with brighter, more radiant flowers. The “cheerful” yellow flower heads, too, show a close connection to the sun, opening as it rises in the sky, turning with it throughout the course of the day, and closing again as the sun disappears in the evening. On



sunless, dreary days, the flowers stay shut. When the innermost florets have faded, the flower head goes brown and dry, the florets are pushed out, and the receptacle closes like a bud. Several days later it opens again dramatically, folding back toward the ground, while the flower base arches upward to form a transparent, quartz-reminiscent, crystal-like sphere. Totally oriented to the world around, the brightly shining, umbrella-like pappi carry the seeds far out into the light and air.²⁰

Let’s move briefly to one more growth-form among the plants, those that build very powerful shoots, the trees; the larch (*Larix decidua*) provides an interesting example. Like their fellow conifers (spruces, firs, pines), larches build a strong central shoot (the trunk) to which all peripheral branching appears subsidiary. Among the conifers, the larch distinguishes itself by having the highest silica content. Thus, it is not astonishing to find both that the larch is lighter in color and more open to the passage of light than other conifers and that it shows a very different relationship to the yearly sun-rhythm from its close relatives. Whereas the others are known as “evergreens” because they hold on to their foliage through the darkness of winter and for years to come, the larch, synchronous with the decline of the sun, sheds its linear leaves in the fall with a luminous show of sun-gold color.²¹ Not surprisingly, larches seek out the light-intense, high country of the mountains to be their home.²²





Larches in the fall

Silica and the Animal World

Although at work in all animals, for example in the fur of mammals, the gesture of silica appears in a particularly striking manner in two animal groups: radiolaria and birds.

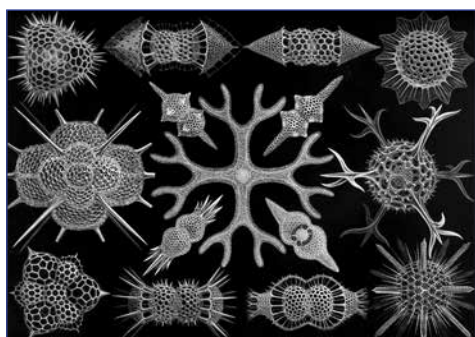
One group of protozoa, the radiolaria, reveals a striking silica gesture in their miniscule silica-containing exoskeletons, which, corresponding to their name, are very ray-like. This gesture is particularly evident when compared with another group of single-celled marine organisms, the foraminifera. A fundamental difference between the two groups is that foraminifera draw calcium out of the water to form their exoskeleton, whereas the radiolaria draw silica. In contrast to the spiny, ray-like radiolarian forms, the foraminifera have an inward-turned, chamber-like appearance, which is quite typical of calcium-permeated structures such as the shells of

snails and clams. The glassy exoskeletons of the radiolaria make a very different impression, one characteristic of silica.²³

The linear, radial gesture in horsetails, grasses, and radiolaria reaches a new level in the birds. As is commonly known, birds are able, by means of their feathered wings, to lift themselves fully into the realm of light and air, where oxygen is all-present and ceaselessly active. What is less familiar is the detailed, silica-permeated nature of the feathers that makes this possible. Looking at a single feather, we find a central axis, the hollow shaft (*rachis*). From this axis extend many linear branches, the barbs. Each barb branches many times again into barbules. In flight feathers, the barbules contain a series of miniscule hooklets, the barbicels, that connect into the barbicels of the neighboring barbules, thus creating an intricately interwoven, unified surface. Taken together, the overall network of all these barbs and barbules results in the vane of the wing.

If we consider that most birds contain an unusually large number of such complex structures (the house sparrow, [*Passer domesticus*], for example, has approximately 3500 feathers), and that they are replaced yearly, it becomes apparent how a bird is constantly weaving together a silica-rich network of countless radiating and crossing linear feather-elements throughout the course of its lifetime. Amazingly, the intricate web is created out of an absolute minimum of substance. The 3500 sparrow feathers weigh, after all, only two ounces. In this silica-based feather world, form is clearly victorious over matter.

The bird's completed feather "gown" is a nonliving tapestry of astounding complexity that needs no metabolism, no blood circulation, no respiration. The life processes of the bird remain close to its core, while it engages the light-filled atmosphere with a lifeless, silica-rich web of radiating, interwoven fibers.^{24,25}

Radiolaria (silica) from *Kunstformen der Natur* (1904) Ernst Haeckel

Foraminifera (calcium)



Silica in Humans

In human beings silica already plays a significant role in the early phases of existence. In the words of anthroposophical physicians Friedrich Husemann and Otto Wolff,²⁶

...[T]he presence of silica is needed particularly when the human form is being created from the undifferentiated embryonic tissue. The formative forces do not work from within the embryo but from outside via the membranes, where the concentration of silica is exceptionally high.²⁷

Human skin is rich in silica, as are hair and nails. Once again, we find ourselves in a realm that engages the light-filled outer world and, in the case of hair, shows significant radiality. The quality of silica is revealed most strikingly in the human eye. Here we see an archetypical expression of silica, reminiscent of the quartz crystal embedded in the density and darkness of the earth's crust. In the human eye, with its crystalline lens, we find light-open substance embedded in hollow cavities of the skull. We see how our silica-rich periphery creates a boundary to the outer world through the all-enveloping skin, and yet, through the sense organs embedded in that skin, opens itself to the manifold qualities of the dynamic, light-filled world around us.^{28,29}

The contrast one finds between the silica-permeated periphery of our body and its more internal, calcium-rich skeletal structures is also

revealing. Ernst Lehrs sums up the distinctive ways in which silica and calcium work in the human organism with the following image:

... [O]ne is inclined to speak of two "gestures" of nature: the gestures which we as humans carry out when we either stretch out our arms and spread our fingers while lifting our head with wide-open eyes, or when we contract our whole body, while lowering our head and dropping our eyelids. These are, in fact, precisely the functions exerted by silica and calcium in our organism. Silica is at work wherever the organism opens itself to the outer world: in the ray-like spread of hair, in the skin permeable to air and light, and especially in the eyes. ... Calcium in the human organism, however, is always used inwardly for the formation of bones.³⁰

Silica in Technology

Looking back, we discover that a non-crystalline form of silica, flint, was central for humankind for thousands of years. This was because, when struck in the right manner, flint flakes into a sharp cutting edge, thus making it very suitable for tools like axes and arrow heads.

More recently, silica has been used as the main ingredient in one of the most beautiful and practical substances on earth: glass. Strong and yet transparent, glass can function in the most varied ways. One in particular, the light-open window in the middle of a solid opaque wall, is strongly reminiscent of the transparent windows of the soul embedded in the middle of the human skull.³¹ Not only does glass remind us of the eyes, but it is also used in service of them. More than just allowing light to pass through, glass is able to shape it, thus enhancing our vision through glasses, microscopes and telescopes.³²

Silica has also revolutionized the watch-making industry, which puts to use quartz's amazing constancy. If you pass electricity through a quartz crystal, it oscillates at a precise frequency of 32,768 times per second. In a quartz

clock a battery sends electric signals to a quartz crystal, causing it to vibrate at that frequency. A microchip circuit detects these vibrations and turns them into standard electric impulses that drive the rest of the clock mechanism. Quartz shows amazing regularity here and is essentially independent of temperature variations and the influence of gravity changes, both of which are issues for the pendulum and balance wheel

clocks of the past.³³ Quartz's unbelievably consistent micro-vibrations thus provide the basis for an exact, unit-based time, for a translation of spatial movement into time quantities. Our dynamic, cosmic time-keeper, the sun, is thus converted into useful, but rather inflexible, earthly increments. For such tasks we can, literally, count on quartz.

In the latter half of the 20th century, technology moved beyond silica, as such, to focus on one of its two constituents, silicon. To do this, massive intervention was necessary. The light-open substance that we have considered from various angles was broken down into its chemical elements, removing the oxygen and leaving only the metalloid silicon behind. Due to its significance in the development of electronic devices, this metalloid is seen by many as the most important technological material of our time. Some speak of our era as "the age of silicon."

In order to free silicon from its natural partner oxygen, quartz must be heated to over 2500°F. This is done in special ovens that are purged with argon gas to eliminate any air. The molten silicon is spun in a crucible into which a small seed crystal is placed. Slowly removed as the silicon cools, large crystals result that often weigh several hundred pounds or more, creating ingots some six feet in length. These are cut into extremely thin slices, called wafers, of only a few hundred microns. After further purifying measures, such as buffering, the wafers are

etched with circuit designs through a process known as photolithography.³⁴

Silicon Ingot

No longer open to the light due to the absence of silica's oxygen characteristics, silicon is now open to the passage of electricity, although not to the same degree as pure metals. It is called a semi-conductor because it can be

manipulated in its conductive properties through a process where pure silicon is "doped" with trace amounts of carefully chosen impurities, such as arsenic or boron, which change its properties, allowing it to function between the poles, of openness to electric conduction on the one hand and, on the other hand, of glass-like resistance to it as an

insulator. Because the semi-conductor silicon can conduct as well as insulate, silicon chips conform to the on/off form of digital logic (binary code) that is used to transmit information electronically, thus making them the crucial component in today's electronic revolution.³⁵

Silicon wafers doped with "impurities" are also used in solar cells. For example, a thin silicon wafer doped with negatively charged phosphorus (N-type silicon) can be placed over a wafer doped with positively charged boron (P-type silicon). When light hits this solar cell, an electric current is created that flows across the juncture of the two layers.³⁶

In Conclusion

Looking back at the various manifestations of silica considered above, we can discover certain gestures that tell us about silica's role in the great book of nature. As a starting point, it is not without significance that silica turns out to be the dominant substance in the makeup of the solid earth, but not merely in a quantitative sense. Silica is "the" substance that, despite its earthly nature, opens itself to the light. Silica thus

Our dynamic, cosmic time-keeper, the sun, is thus converted into useful, but rather inflexible, earthly increments. For such tasks we can, literally, count on quartz.



brings the element of light into the darkness of earth. It does this with great hardness but with surprisingly little density. In short, a relationship between the cosmic light (sun) forces and the depths of the solid earth is mediated by silica.

Moving to the plant world, we find silica opening the green plant to the light-embodying process of photosynthesis, thereby helping to incarnate

light forces into living substance. Silica is particularly active in the structural integrity and ray-like linearity of grasses (and other plant stems) that we find growing upward toward the sun. Indeed, the growing tip of the central shoot is “heliocentric” (oriented toward the sun and its movement), in contrast to the earth-centered “geotropism” of the plant’s root system.³⁷ In the dandelions and larches, too, a silica-mediated light affinity is evident.

In the animal kingdom the linear, ray-like gesture of silica speaks clearly in the minute world of the floating radiolaria and “begins to sing” in the tapestry of silica that carries the birds aloft. In both instances, formative forces of light hold sway over the density of matter. In humans (and higher animals, too), silica resides largely in the periphery, in the hair (fur) and skin, in the sense organs, and, most tellingly, in the light-open cavities of the eyes.³⁸

From the solid earth, to the plants, to animals, and to humans, we find silica mediating between the cosmic light forces that ray down to the earth and the forces of solid matter below. The presence of silica makes possible the interplay, the interpenetration, of the cosmic and the earthly in a significant way.

From the solid earth, to the plants, to animals, and to humans, we find silica mediating between the cosmic light forces that ray down to the earth and the forces of solid matter below. The presence of silica makes possible the interplay, the interpenetration, of the cosmic and the earthly...

In the technological use of silica, we see this character most clearly in glass windows created so that light can enter into the interior of spaces that otherwise separate us from outer world.

This profound role of silica as facilitator of nature’s earthly/cosmic interactions changes when we use artificial means to bring forth a chemical element that does not “naturally” exist in nature: pure silicon. By forcefully removing the oxygen from quartz, we create a substance that is not only not open to the light, but that even reflects it to a large degree. When treated with miniscule amounts of certain substances (doping), it can turn that light into electricity. Rather than letting the light shine through as silica does, silicon captures the light and transforms it into electricity. Since this process

transcends anything that we can experience directly, it is interesting to hear Rudolf Steiner’s description of what is taking place: “When one drives light into the sub-material, into a level below the material world...then electricity comes about. Light is compressed in the most extreme manner. ...”³⁹ Using the chemical/technological means at our disposal, we have brought about a process that reverses the “natural”

effect of silica: Instead of *opening* the material world to the forces of light, the forces of light have been, in Steiner’s description, *compressed* to the extreme and driven down into a sub-material realm. We are still working with the relationship of light and the material world, but in a very different way. It is true, of course, that this electricity can be used to create new light sources, as Thomas Edison revealed to the world in a dramatic fashion, but the larger implications of “compressing” light forces into electricity are certainly worthy of further reflection from a spiritual scientific perspective.

ENDNOTES

1. To clarify at the outset, confusion often exists between the terms *silica*, *silicon*, and *silicone*. As will be explained in the text, silica is another name for quartz. It is a chemical compound found in the earth. Silicon is a chemical element not found in nature, but which arises when silica is analyzed (broken down) into its chemical constituents silicon and oxygen. (See text for more detail.) Silicone is a synthetic polymer used in synthetic rubbers and lubricants.
2. Chemically, silica is known as silicon dioxide, SiO_2 .
3. This abundance stands in striking contrast to the third most prevalent element, aluminum (7.5%), the fourth, iron (4.7%), and in fifth place, calcium (3.4%). Further down the line we find such well-known elements as hydrogen and phosphorus at less than 1% and carbon, sulfur, and nitrogen at less than 1/10th of a percent.
4. Hardwick & Bouillon 1997.
5. By comparison, the hardness ratings of gold and copper fall between 2.5 and 3, and iron's between 4 and 5 on the Mohs scale.
6. This surprisingly low density becomes evident when compared with several familiar metals.
 - Iron melts at 2795°F but has a density of 7.87;
 - Copper melts at 1985°F with a density of 8.84;
 - Gold melts at 1948°F with a density of 19.3;
 - Silver melts at 1764°F and has a density of 10.5.
7. These characteristics it shares with nitrogen, its primary partner in making up the earth's atmosphere.
8. Challoner 2015; Parsons & Dixon 2014; Kranich 2005; Julius 2000.
9. Cloos 1976, p. 11.
10. Julius 2000, pp. 154–155.
11. Silicates are a mineral group comprised of a basic silicon-oxygen unit (SiO_4) that combines with a range of metals (Al, Fe, Ca, Na, K, Mg, Ti, Mn, B, Be) to form large families of silicates, such as feldspars, olivines, micas, and hornblendes. Hancock & Skinner 2000.
12. Photosynthesis is a process by which light forces are embodied in the plant in conjunction with the synthesis of carbon dioxide and water to form carbohydrates.
13. In contrast to Horn Manure prep (5500), which is applied to the soil. Koepf 1971.
14. Biodynamie Services, 2016; J. Porter Institute 2016; Koepf, 1971.
15. Castelliz 2008; Bockemuehl & Jarvinen 2006; Grohmann 1974.
16. Silica is deposited in the periphery of the plant, strengthening the cell walls and epidermis. Koepf 1971.
17. Holdrege 2009; Kranich 1995.
18. Kranich 1995; Goethe 1988; Julius 1969.
19. The ash of the dandelion is 7% silica. Pelikan 1975.
20. Bockemuehl & Jarvinen 2006; Pelikan 1975.
21. The sun-loving larches also happen to be strong producers of Vitamin C.
22. Where they and the Arve (*Pinus cembra*) populate the uppermost tree-line. Ellenberg 1978; Pelikan 1975.
23. Lehrs 1958.
24. The ash of bird feathers contains 10-40% silica, whereas human hair contains 6–30% silica. Kaufmann 2013.
25. Portmann 1984; Kranich 2005; Julius 2000.
26. Husemann & Wolff 1987.
27. The ash of the amnion is 22% silica, for example.
28. Ernst Lehrs points out that the lens of the eye, "...not for nothing called the "crystalline lens," actually consists of fibres, which in their cross-section have the same hexagonal shape that is found in rocks based on silica." Lehrs 1958, p. 228.
29. Husemann & Wolff 1987; Cloos 1976.
30. Lehrs 1958, p. 226.
31. Challoner 2015; Parsons & Dixon 2014; Julius 2000.
32. Julius 2000.
33. Challoner 2014.
34. Challoner 2014; Huber 1982.
35. Ibid.
36. Challoner 2014.
37. In his *Agriculture Course* Rudolf Steiner characterizes for the farmers the formative influence of silica in the following way: "If we were to assume for the moment that we had only half the amount of silica in our environment, then we would have plants that were all more or less pyramid shaped!...The grasses (cereals) would look very strange, their shoots would be thick and fleshy below, the upper flowering region stunted and incomplete." Steiner 1975, p. 36.
38. In Schiller's (1962) words:

"Can you name me the crystal?
To no other can it be compared.
It sends forth light without ever burning,
The cosmic all it draws within.
The sky itself is painted on it,
Is painted on its wondrous ring,
And yet what rays forth from it
Has more beauty than it taketh in."
(transl. MH)
39. Cited in Gebhard 2005, p. 281.

REFERENCES

- Benesch, F. & Wilde, K. (1995). *Silica, calcium, and clay*. Schaumburg, IL: Schaumburg Publications.
- Biodynamie Services. (2016) Horn Silica (501). <http://www.biodynamie-services.fr/en/biodynamic-preparations/horn-silica-501.php>.
- Bockemuehl, J. & Jarvinen, K. (2006). *Extraordinary plant qualities for biodynamics*. Edinburgh: Floris.
- Castelliz, K. (2008). *Life to the land*. Great Barrington, MA: SteinerBooks.
- Challoner, J. (2014). *The elements*. London: Carlton Publishing Group.
- Cloos, W. (1976). *Kleine edelsteinekunde*. Stuttgart: Verlag Freies Geistesleben.
- Ellenberg, H. (1978). *Vegetation mitteleuropas mit den Alpen*. Stuttgart: Ulmer.
- Grohmann, G. (1974). *The plant*. London: Rudolf Steiner Press.
- Hadwick, E. & Bouillon, J. (1997). *Introduction to chemistry*. Orlando, FL: Saunders College Publishing.
- Hancock, P. & Skinner, B. (2000). *The Oxford companion to the earth*. NY: Oxford University Press.
- Holdrege, M. (2009). *From beach to savanna*. Ann Arbor: Proquest.
- Huber, J. (1982). *Der verlorene unschuld der oekologie*. Frankfurt: Fischer Verlag.
- Husemann, F. & Wolff, O. (1987) *The anthroposophical approach to medicine*, Vol. II. Hudson, NY: Anthroposophic Press.
- Josephine Porter Institute. (2016). Horn-Silica. <https://jpbiodynamics.org/product/bd-501-horn-silica-spray-preparation>.
- Julius, F. (1970). *Das tier zwischen mensch und kosmos*. Stuttgart: Verlag Freies Geistesleben.
- Julius, F. (2000). *Fundamentals for a phenomenological study of chemistry*. Fair Oaks, CA: AWSNA.
- Kaufmann, H. (1953). *Arzneimittel synthese*. Heidelberg: Springer Verlag.
- Koepf, H. (1971). *Biodynamic Sprays, Bio-dynamics*, #97, Winter 1971.
- Kranich, E. (2005) *Chemie verstehen*. Stuttgart: Verlag Freies Geistesleben.
- _____. (1995) *Wesensbilder der tiere*. Stuttgart: Verlag Freies Geistesleben.
- Lehrs, E. (1958). *Man or matter*. London: Faber & Faber.
- Parsons, P. & Dixon, G. (2014). *The periodic table*. New York: Quecus.
- Pelikan, W. (1975) *Heilpflanzenkunde*. Dornach: Philosophisch-Anthroposophischer Verlag.
- Portmann, A. (1984) *Vom wunder des vogellebens*. München: Piper.
- Steiner, R. (1975). *Geisteswissenschaftlicher grundlage zum gedeihen der landwirtschaft*. Dornach: Rudolf Steiner Verlag.
- Schiller (1962). *Raetsel aus turandot*. Sämtliche Werke, Band 1, München S. 443,447.
- Stwertka, A. (2002). *A guide to the elements*. Oxford: Oxford University Press.
- Voronkov, M. et al. (1975) *Silizium und leben*. Berlin: Akademie Verlag.

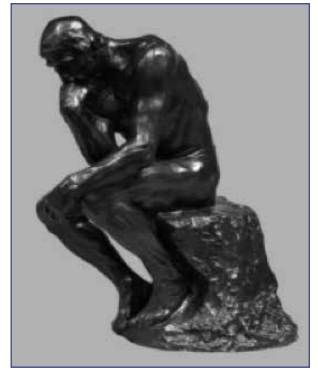
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Technology and the Laws of Thought

Gopi Krishna Vijaya

τέχνη (*techne*): art, craftsmanship, skill
λογική (*logike*): reason, rational thought

In the past couple of decades, the globe has been encircled by the web of technology. Devices have become obsolete so blindingly fast, that coming to grips with the pace of development has become tougher with time. It is not uncommon to feel as if one is on a roller coaster ride, hanging on to the seat by the tips of the fingers. From around the time Alvin Toffler's *Future Shock* became popular in the 1970s, several hundreds of books have been written, talks have been arranged, conferences organized under the theme of technology, especially about computing technology that has come to influence our lives so penetratingly. However, the glare of new technology has grown so strong that most descriptions restrict themselves to the past 50 years or so, as it is not worthwhile to describe and study an obsolete technology in full working detail. Even if the earlier history is mapped out,



the corresponding conceptual development, particularly the philosophical development, is not generally addressed.

Additionally, innovation has been a goal much stressed in recent years. In a rapidly changing environment, it is doubly difficult to identify what is really new, making it a tricky goal to work with. Hence what are most needed are an analysis of the way we came to be where we are today in terms of technology and a clear understanding of what the effect of technology is on the human mind. Only this context can show where we are headed.

These two aspects are addressed in this work: how the technology was created and how it is related to the thinking process. Not only is a historical overview provided, but the conceptual developments which came into being along the way are highlighted as well. This is seen to lead right back into the time of the Renaissance and the Age of Enlightenment, and by suitably arranging the different streams of thought so that their effect on each other can be seen, we

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can find a way into the much distant past—to the origin of the ideas guiding technology today. This path can get winding at times, but it is by no means random. The aim of the process is to see both if the way technology has developed was the only way possible and if any ideas can give a different orientation for it. At the same time, studying the effect of machines on the human mind can suggest ways to understand and to compensate for these effects. Such study should help not only to tackle technology in the right way, but also to enable new ideas to enter into this field that can prove fruitful for every free-thinking person.

The real question is not whether machines think but whether men do. The mystery which surrounds a thinking machine already surrounds a thinking man. – B.F. Skinner

The Situation Today

One of the distinguishing features of the world today is the sheer number of distractions one is subjected to day in and day out. Every aisle in the supermarket has a thousand options, every street in the city has a thousand boards and advertisements, and every click of the button pours out myriad options for pursuit. The sights and sounds that blare forth from all directions, especially in the midst of a big city, have reached unprecedented levels, especially when all the earphones and small-screens are included. This development is noticed not only by the experts in psychology and the students of anthropology, but also by the general public. The sudden rise of electronic media and its consequences can hardly be missed by anyone. This transition into the world of distraction is being experienced by a larger section of the population today than ever before, and quicker than ever before.

As the things that demand our attention have proliferated, attention spans appear to have gone the other way. In just the last fifteen years, it can be observed that it is much harder to concentrate on only one topic at a time, in any field of life. In

order to accommodate, and to somehow work with this limitation, the fields of knowledge have gradually splintered into innumerable tiny boxes. Observe the number of specialists that have arisen in the various fields of knowledge; e.g., “a doctor” is not to be found easily, but rather an “-ologist,” whose specialty is one specific part of one specific organ of the body. It is difficult for a scientific investigator to even understand the vocabulary of another field of science, let alone communicate the thoughts accurately. It is actually easier to be “the expert” of a narrow topic than to have an in-depth grasp of a wide array of knowledge. This appears to be one of the side-effects of the Information Age: a fracturing of knowledge and attention. On one hand, the ability to access information has increased enormously, and on the other hand, the ability to remember, assimilate, and work with that information is more and more challenging.



(courtesy Manu Cornet)

Noticing this change is one thing; coming to terms with it is quite another. It is clear that with time, these effects of technology can only increase, which brings up several questions. How did this technology arise? Where did it originate, and where is it headed? How do we distinguish the harmful and useful effects of technology? Where is it possible to draw the line, if at all such a line exists?

It is possible to think about technology in simple terms, for example: the knife that is in the hands of a surgeon and the knife that is in the hands of a robber. If so, then it is not the knife that is the issue at hand, but the person and his motives, in which case all worrying about technology becomes irrelevant. However, things are not as simple as all that when comparing a knife with the effects of modern computing technology. The effects of a knife are clear and visible to all, while the effect of technology on the workings of the innermost aspects of the mind is not easily visible. The cooperation with the machine remains out of sight. Studying the *visible* effects of technology is easier than understanding the *invisible* effects on something as internal as thinking and focusing. Computing technology is, as the saying goes, a whole 'nother animal.

Therefore it is important to identify what the relationship is between thinking capacities and our current technology-filled life, and what can be done about it. This is a vast field, and it would involve delving into an obstacle course of sorts to trace the origin of the relevant ideas. Since these developments are not easily visible to the eye, it requires some patience to identify the path to trace. Hence, a good approach would be to consider the changes themselves in greater detail and try to get a clear image to work with. The right questions can reveal themselves along the way, instead of trying to force-fit the situation into specific questions. Since the topic is about



the recent changes in thinking capacities, we will begin with the present day and work backwards.

Since the path of approach is not easily visualized in the case of internal thought processes, the first thing to do is to study the current scenario in a bit more detail. The ideal place to start the inquiries is with what is right

“in our face,” i.e., the “screen” on which you are reading this. It could be either a paper or (more likely) the computer screen. If you are reading hard copy, most likely it was printed from a computer after selecting it on the screen, which leads us back to the computer screen, a good starting point.

In general, what would the response be if a person is asked today: “How does this screen work?” The chances are that “how computer screens work” would be typed into a search on Google, Wikipedia, or perhaps howstuffworks.com. Within a few minutes, everything related to the computer screen will be available, right from the pigments on the sheets that make up the screen to the way the screen is refreshed. A YouTube video might even provide a look into the cross-section of the screen. Everything appears very straightforward. However, imagine the situation after a week. When the same question is asked, what would be the likely result? Of course, a person might remember “googling” it, but remember the details only vaguely, and would probably do a quick re-search to provide the answers. Similarly,

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after a month... It is likely that the person would be halfway through an article on screens, and then realize: "Hey, I have read this before! Some time recently..." Hence, there is a definite observable variation in both memory and understanding.

Now, let it be further assumed that a project report is required on the same topic, "How Display Screens Work." What would be the obvious approach? Most likely it would involve clicking on a lot more links and perhaps a visit to the library. Discussion with others would occur through email, online forums, and social media.

The report would be typed up on a computer, reorganized, edited, proofread, and submitted via email. We can imagine a student completing the entire project on a laptop without even leaving the bed. In other words, it might not even be necessary to move away from the computer screen, in order to understand how a computer screen works! At the end of it all, if there are 200 people completing such a project today, how many would have involved actually taking apart an old computer screen? And how many would involve links picked from the first page of results in Google? It is worth pondering that for a moment.

Now, consider taking a few steps back, about 30 years into the past, in order to compare it with the situation today. Imagine the results of the previous project as written by 200 young students in the 1980s, who embark on such a project. To stay true to the different time periods, assume that the students of the 80s have a project to submit on the *television* screen. Imagine the movements of the students in the library; it is easy to see several different starting points from different books, involving a lot of physical movement to and from bookshelves, to study desks and perhaps coffee shops. Probably a good number of the students would be in the junkyard, pulling out spare parts of

a discarded television set. A typical student would have at least travelled from the house to the library to look up references. In the writing process, from one sentence to the other, there would have been a lot of time involved. Every sentence would have had to be first thought out, discussed, and then written or typed out with care, with little correcting (save for typos). The sentences spent a lot more time in the mind before getting transferred to paper. In addition, a considerable amount of activity, both mental and physical (muscular) activity, was involved in the process. There is quite a big difference

between planning a bus ride to the library among several other chores and the push of a button. Hence, these two aspects can be seen to clearly distinguish between the two eras: the element of *time* and the element of *effort*.

The next step is to confirm this observation by considering an even earlier time period.

By moving back 50 more years into the past, somewhere in the 1930s, we can visualize a different scenario. Consider a slightly different project for the student of 1930: to identify how the cinema worked, for example (keeping the theme of screens alive). At this point, there were virtually no technical aids to the thinking process itself, except one's own capacities, books, and slow-paced communication with other people. There were only a few machines that the average student could use to help him, perhaps the local press and the radio. The practical side would have likely involved actual protracted work with cinematic equipment and projectors, which were not owned by many people at the time. It would have been necessary to learn to operate the instruments related to projecting an image on the screen in the cinema hall itself, the effort and scope of the project magnified and the time taken for it likewise lengthened.

Thus, time and effort involved in any mental activity are seen to increase for every decade

Time and effort involved in any mental activity are seen to increase for every decade traveled into the past.

traveled into the past. It is a common experience for those who communicate with their grandparents to marvel at the amount of effort even simple tasks took in their time. Of course, this is no great revelation, because, after all, a machine is an object that saves human time and effort. The important point here is to have a clear visual of the inner *mental* situation with regard to this requisite time and effort, as this is the part that is not readily visible.

At the same time, when we observe devices other than computing devices, we see a comparatively slower evolutionary process. For example, the shape of the knife has not really changed in several centuries. Even automobiles, airplanes, bicycles, and ships have all sustained their basic structure for nearly a century. It is mainly with computing technology that the pace of change is accelerated so tremendously. Since all technology before the computers helped to assist physical work, the possible reason for this accelerated speed has to be related to its connection to the human thinking process. That is the conclusion one is led to when comparing rates of change of technology: The speed of evolution of technology that is related to mental activity far outstrips the evolution of other forms of technology.

In addition to changing much faster than conventional “visible” technologies, computing technology has also absorbed the activity of older devices into itself. For example, a good comparison between the situation before and after the turn of the century can be seen in this picture:

Observe that the working office or study desk has become “virtualized” and sucked into the computer and the Internet. This is the major difference between the tools used in the middle of the 20th century and the tools used today: Most of the tools have been replaced by the computer. For most projects involving mainly analytical thinking, in place of the library, the office desk, the telephone (and perhaps even the television), there is one instrument: the



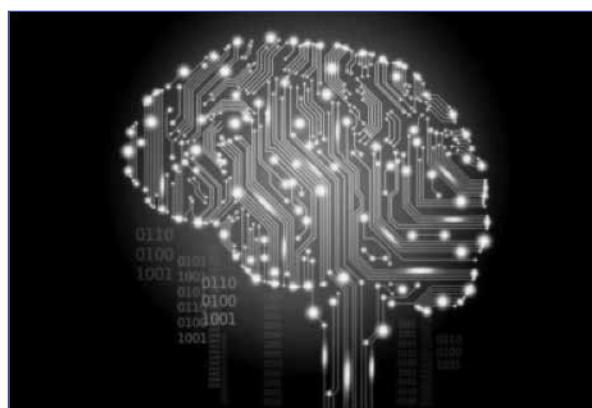
computer. Thus, the focus would have to be on computing technology, with other forms of technology remaining in the background.

It is important to visualize this entire process clearly: how a project is approached, started, and finished in today's world. The patterns of thought used in implementing this technology lead to the central issue: How exactly does a computing machine affect the human thinking process? And how is this effect different from the effect of other machines?

Internal and External Effort

For it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anyone else if the machine were used. – G.W. Leibniz

Before the age of machines, it was the work animals that provided the motive force for all of mankind's activities. Once the machines took



over, the burden of generating power fell on inanimate processes. What would once have taken many people months of back-breaking, repetitive work could be accomplished with the help of moving a few levers and buttons. In addition, up to about a century ago, what the machines took over was almost always related to some skeletal or muscular movement of the human body. The six simple machines, as most of us were taught in grade school, all replace movements of one kind or another carried out by the muscles and bones of the human being.

- Wedge (fingers)
- Pulley (joint movement)
- Inclined plane (tilting)
- Lever (arm, knee)
- Screw (wrist)
- Wheel and axle (rotating joint)

So, it can be said that movements of the hands and legs are “outsourced” to the machines and multiplied. This is the origin of technology in its conventional form, as it existed until the 19th century.

However, manual effort is not the only kind of effort that exists in this world, as anyone who has struggled for hours on end with a mathematics problem will gladly attest. This was also seen in the comparison of the TV-screen project report from decade to decade. In this case, effort belongs to the thought process alone, which does not pass over to the limbs. It is here that the apparent difference between a thought process and a mechanical movement of the skeleton and muscles can be observed: one is *internal*, the other *external*. For the time being, the words “internal” and “external” will be used to indicate only their general nature as a matter of experience, and whether or not the two are strictly distinct will be examined in a later chapter [Part 2 will be included in *Research Bulletin XXII-1*, Spring/Summer 2017.] In terms of experience,

most analytical, scientific, or meditative effort is directed at the cultivation of internal effort for producing results, while athletic and gymnastic efforts are directed at the cultivation of external effort.

Humanity spent large periods of time when bodily effort determined daily life to a great extent. However, skills were developed over a

Movements of the hands and legs are “outsourced” to the machines, and multiplied. This is the origin of technology in its conventional form, as it existed until the 19th century.

period of time which prepared the way for the formulation of the laws of mechanics and the rise of technology. This indicates that just as the laws of mechanics were formulated after several generations of men and women had steeped themselves in the work of building various structures, what is external work at one point of time evolves into a capacity for internal effort at a later point of time. It is quite possible that

Galileo had never had his hand crushed by a boulder or spent years building a tower, but that did not prevent him from observing the laws of falling bodies. This indicates the important transformation that occurs from age to age: External bodily effort of one era transforms into the capacity for inner effort of a later era. (It is important to note at this point: External effort develops only the *capacity* for inner effort, not the effort itself! It is up to the individuals to develop that, a fact which will be examined in the later sections while expanding on the vague term “inner effort.”)

As the external work got outsourced to the machines as technology, mathematics and natural science bloomed parallel to it. This period continued from the 16th century until the end of the 19th century, when a new idea entered mankind: Is it possible to outsource the inner effort of *thought* to the machines as well? Side by side, another idea was also taken up seriously: What if my so-called inner effort or willpower is nothing but a mechanical effort of my own mind? In other words, what if my mind is a machine?

While pursuing these questions, we must analyze the process of outsourcing thinking. An overview of this process reveals that first such machines were used purely as calculating machines or calculators, to supplant the rote calculation that was done before then. What followed was the creation of calculating machines whose rules of calculation could also be included within their operation, i.e., programmable machines or computers. Further, the programmable machine has served as the “nervous system” of all other machines, helping to interface several of them at once. It has thus been possible to merge the functionalities of several devices into one device, as shown in the earlier illustration about social media. Ever since then a great controversy has been raging as to whether the mental capacities of a machine are comparable to human mental capacities, or not. Currently, the computer leads technological revolutions, as every process in the world is reproduced within the computer, and the computer also generates new data never generated before.

This phenomenal success of computing has also given rise to the notion of computers “becoming conscious/self-aware” or even coming to life. In other words, life processes are seen as

a combination of extremely complex mechanical interactions, and since computers perform these calculations in a fraction of a second, would it not be feasible to call a computer *alive*? These and many other related questions have cropped up in the past few decades with increasing intensity.

Essentially, the key question is regarding the thinking process itself. How *does* a human being think? Once the process is understood, it is only then that a comparison with the computer can be correctly made.

Hence it is necessary to trace the idea of computers, or “thinking machines” as they were called earlier, until a clear view is obtained of the thought process itself. The route can be taken backwards in time as follows: Starting with

social media (2000s), which involves interfacing several profiles over the Internet, one can work back to the idea of the Internet, which was first developed (from the late 1960s to the early 1990s) by several computer engineers to connect the data among universities. Since this interconnection duplicated the single computer, it is necessary to trace the development back to the inspiration for the computer. Prior to the 1960s, the milestones in this development can be outlined in the following chart:

This indicates the important transformation that occurs from age to age: external bodily effort of one era transforms into the capacity for inner effort of a later era.

Year	Concept	Pioneers
1945	Computer architecture Programming	John von Neumann, Grace Hopper
1937	Switching theory	Claude Shannon
1936	Computability of numbers	Alan Turing
1931	Incompleteness theorems	Kurt Gödel
1879	Symbolic Logic	Gottlob Frege, Charles Peirce
1847	Digital logic	George Boole
1670	Mathematical logic, binary numbers	Gottfried Leibniz
1642	Calculating machine	Blaise Pascal
1641	Mechanics, coordinates	René Descartes
1601	Binary codes	Francis Bacon (Lord of Verulam)

There is a gap of about 200 years leading up to the Age of Enlightenment (mid-1600s), when mechanical calculators were first developed. In the same period, philosophy played a strong role in generating these ideas, involving, for example, the beginning of mathematical logic. So the Enlightenment era, during which the first seeds for today’s technology were laid, is a good place to start the analysis. Starting from this time period, one can progress forward to the present, paying attention to the developments and the pioneers who developed them. The course of the path, as well as the contribution of each pioneer, will now be analyzed, keeping in mind the relationship with the thinking process throughout the analysis.

Ideas behind “Thinking” Machines

For by this Art a way is opened, whereby a man may expresse and signifie the intentions of his minde, at any distance of place, by objects which may be presented to the eye and accommodated to the eare: provided those objects be capable of a twofold difference onely; as by Bells, by Trumpets, by Lights and Torches, by the report of Muskets, and any instruments of like nature. But to pursue our enterprise, when you addresse your selfe to write, resolve your inward-infolded Letter into this Bi-literarie Alphabet. – Francis Bacon, 1623

Language is the mode used to communicate human thoughts. Hence it is essential, while studying the development of thinking processes,

to study the mode of their communication in every time period.

The foundation for the modern day communication device—the computer—is the binary code system, which originated in the methods for passing secrets and codes, i.e., in cryptography of the 17th century. Binary numbers as a mathematical system were explored in ancient cultures and even tribal societies while using different “bases” for a number system, such as 2, 10, 12, 16, and 60. However, it was the idea of Lord Bacon of Verulam to associate an alphabetical character to a binary code, thus bringing mathematical application into language. Base 2 was the most natural base to use, as most physical objects can be affected in that fashion, e.g., “by trumpets, by lights and torches.”

Bacon’s researches into cryptography brought into culmination something that had begun in several old cultures such as China, Meso-America, and Sumeria: the art of writing. During this ancient period, what was formerly transferred only via the human voice from generation to generation (before 3rd millennium BC according to historians, which marks the start of Sumeria) was engraved in tablets. This occurred in several stages. For centuries following the early stylus marks and hieroglyphs, mankind used *writing* for keeping record. In its earliest stage there was still an imprint of the writer in the particular record: the *handwriting*. It is possible to illustrate a considerable amount of variation within the way something was written down, not in content, but in form, giving rise to various styles of writing, each with its own nuance. Beauty and art played a major role in much of the earlier writing styles, as is evident when calligraphy or even hieroglyphics are studied. This can be called Stage I: the transfer from voice to script. In this stage, as one writer copied what was written down by his predecessor, individual variations in the style of writing (which was predominantly cursive) were naturally present for any particular written content.

Example 3. Of a Bi-literary Alphabet.

Aaaaa,	aaaab,	aaaba,	aaabb,	aabaa,	aabab,
A,	B,	C,	D,	E,	F,
aabba,	aabbb,	abaaa,	abaab,	ababa,	ababb,
G,	H,	I,	K,	L,	M,
abbaa,	abbab,	abbba,	abbbb,	baaaa,	baaab,
N,	O,	P,	Q,	R,	S,
baaba,	baabb,	babaa,	babab,	babba,	babbb,
T,	V,	W,	X,	Y,	Z

This prevailed until the 14th century AD. The next massive variation in communication occurred at the beginning of the 15th century with the invention of the printing press. Now, the “style” of handwriting was “frozen” into the machine, and letters were split up into blocks, which could then be used to produce and infinitely reproduce a particular page. Thus, in this Stage II, individual handwriting no longer mattered. However, there was still considerable variation book to book, language to language, ink to ink, and paper to paper. In spite of the mass production, these aspects made it through.

It is well known that the printing press revolutionized culture, as knowledge penetrated to the masses in a way never possible before, and “literacy” as a social concept came into being. About two centuries after the invention of the press, all personality is driven away from the expression of writing with the advent of Bacon’s cipher, as each character is reduced to “on” and “off,” so to speak. There can be no individual variation possible in the transfer of this code, even if a wide variety of physical objects is used for the transmission. One can light fires, shine mirrors, or bang on drums, and the net effect is the transfer of the same character from one place to another. The “paper” could vary, but there was no leeway for variation in binary code. This is Stage III, which developed later into other forms, such as Morse Code and even Braille. The transformation can be represented as shown in the diagram below.

Hence, mathematics and language became intertwined, with a mathematical construct replacing a letter of the language. The full effect of the individual was diluted in stages: from the

unique human voice, to the varied handwriting, to the standardized letter, to the universal code.

What rose up as the art of printing in the 15th century in Europe happened to be a reflection of an art developed in China in as early as the 3rd century AD. Chinese printing had advanced considerably, but was restricted in its use of movable type because of the immense complexity of its language, which was entirely unsuited for developing a large-scale process. It was in Greek, Latin, and Anglo-Saxon languages that the phonetic script allowed the best possible application of printing. Another idea of Ancient China was, however, much more amenable to an adaptation, which was carried out by the German philosopher, Gottfried Wilhelm Leibniz (1646–1716).

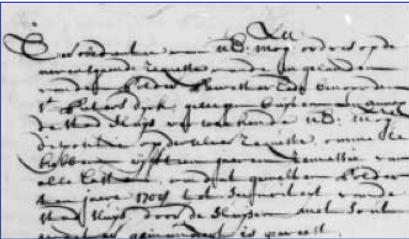
Leibniz, along with his contemporary Newton, is famous today mainly for developing Calculus and for developing the binary representation of digits, which he was studying for application in computing.

He had a deep interest in Ancient China. He studied Chinese writings extensively and is said to have remarked to a friend in a letter, “I shall have to post a notice on my door:

Bureau of Information for Chinese Knowledge.” This fascination with China increased when he encountered the Hexagram arrangement of Fu Xi, which closely mirrored the binary system. Thus, he was deeply influenced by Chinese philosophy



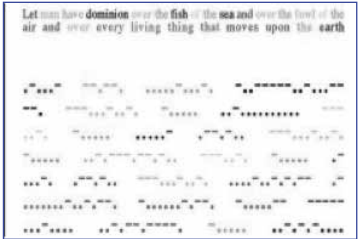
Bagua of Fu Xi



Stage I – Cursive handwriting



Stage II – Printed letter



Stage III – Binary code

in the very work that laid the foundation for modern binary computing.

Of course, Leibniz was also interested in fully functional calculating machines and had even constructed one, much like Blaise Pascal, who had designed one such machine in 1642. These machines employed the well-known system of interlocking gears to add, subtract, multiply, and divide. While Pascal's machine utilized the decimal system, Leibniz also outlined a method for a binary calculating machine:

This type of calculation could also be carried out using a machine. The following method would certainly be very easy and without effort: a container should be provided with holes in such a way that they can be opened and closed. They are to be open at those positions that correspond to a 1 and closed at those positions that correspond to a 0. The open gates permit small cubes or marbles to fall through into a channel; the closed gates permit nothing to fall through. They are moved and displaced from column to column as called for by the multiplication. The channels should represent the columns, and no ball should be able to get from one channel to another except when the machine is put into motion. (Leibniz, *De Progressione Dyadica*, 1679)

While calculation with machines was mainly seen at the time to be an aid to repetitive mathematical work, what is more interesting is the relation to thinking that was happening at the same time. Leibniz was very interested in showing that all statements that express human thought can be represented using a symbolic method, hence forming an "alphabet of thought." He stated his ideal as follows:

... if one could find the characters or symbols to express all our thoughts as cleanly and

exactly as arithmetics expresses numbers, or as analytic geometry expresses lines, one could do the same as one can do with arithmetics and geometry, as much as they are subject to reasoning. This is because all investigations that depend on reasoning would take place through the transposition of these characters and by a kind of calculus. This would make the invention of very nice things very easy...

And the characters which express all our thoughts would constitute a new language which might be written or pronounced. This language will be very difficult to make, but very easy to learn. This language would be the most powerful instrument of reason. I daresay that this would

be the last effort of the human spirit, and when the project will be executed, humans will only care about being happy because they will have an instrument which will serve as much to amplify reason, as much as the telescope serves to improve the vision. (Leibniz, *Characterica Universalis*, 1677)

The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate [*calculemus*], without further ado, to see who is right. (Leibniz, *The Art of Discovery* Wiener 51, 1685)

Leibniz articulated the origin of a second stream of thought, one which strives to convert the reasoning or logical process into a mathematical process. These ideas indicate both the interest in representing thoughts as mathematical expressions and the ideal of a machine that enhances reasoning "as much as the telescope serves to improve the vision." Here,

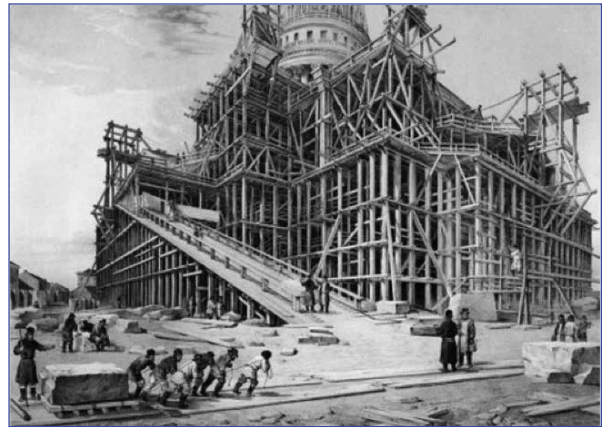
In the case of the calculations necessary to generate extensive mathematical tables, ... a mechanism certainly helps the thought process. Does this however mean that a thought process is *identical* to a mechanism?

thinking and *mechanism* are closely interlinked as an ideal.

Meanwhile, French philosopher René Descartes was convinced that the world was a mechanism and everything in it followed the same laws as those found in a machine. This view saw the material Universe as a gigantic clockwork mechanism, set in motion by the Creator and continuing forever in that fashion. The laws constituted the rules of coordinate geometry and mechanics. However, Descartes believed the mind to be distinct and separate from matter, superior to the mathematical mechanism of the world, while Leibniz considered the process of the mind itself (reasoning) as a mathematical process. Here the two views of relationship of thinking to mathematics are revealed: one which views the thinking as distinct from mathematics and one which views them as being identical for all practical purposes.

This intersection of mechanism, thought, language, and its representation is the determining factor with regard to all computations of the later years. Just as Bacon's ideas were instrumental in making all writing universal and mathematical, Leibniz and Descartes concerned themselves with universal logic and universal mechanism respectively. This theme of Universality, or removal of the expression of human thoughts from the personal sphere to one governed by mathematical laws, guided the development of ideas for technology until the end of the 17th century.

In terms of philosophy, there is a substantial passage of time from these preliminary investigations of Bacon, Leibniz, and Descartes to the developments of Boolean algebra and mathematical logic of the 19th century. While this might give the *appearance* of a gap, it points once more to the aspect of *internal* development hinted at previously, where thinking itself undergoes a gradual change. To trace this internal development accurately, the thought process has to be understood in all its aspects; i.e., thought construction has to be studied next.



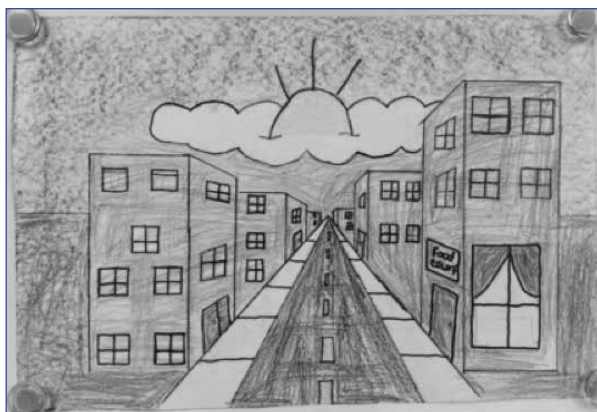
Thought Construction

Un tas de pierres cesse d'être un tas de pierres, des qu'un seul homme le contemple avec, en lui, l'image d'une cathédrale. [A rock pile ceases to be a rock pile the moment a single man contemplates it, bearing within him the image of a cathedral.]

– Antoine de Saint-Exupéry

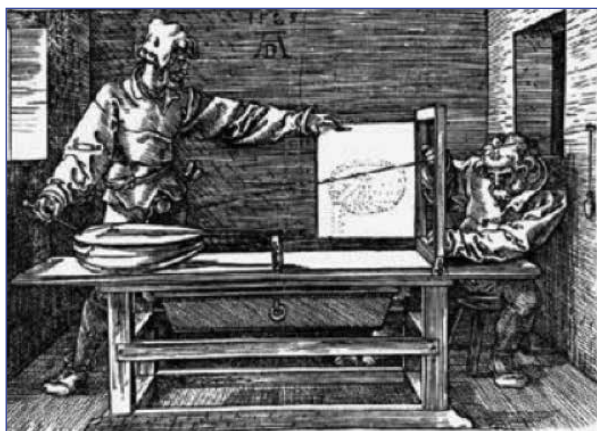
In the previous section I described the transitions that occurred at the end of the 17th century, which served to intertwine logic and mechanisms into a system. The question naturally arises: Is thought a form of mechanism? In the case of the calculations necessary to generate extensive mathematical tables, it is clear that a mechanism certainly can support the thought process. Does this mean, however, that a thought process is *identical* to a mechanism? This is the central core of the problem, and hence has to be addressed carefully.

When considering any topic, particularly the issue of thought, it is important to realize how quickly a worldview transforms. A fact taken for granted today might not have been conceivable two centuries ago, and this is even more true today when a *concept* or idea is taken for granted. Most historical overviews find it difficult to make this transition: not only to describe events of a bygone era, but also to really *think* as the people thought at that point in time. This aspect has to be cleared up before an understanding of the thinking process itself can be undertaken.



Let us begin with some illustrations. Consider the solution of a straightforward problem: How must a drawing be created on a sheet in order to represent a 3-dimensional image? It is clear to anyone today with the slightest artistic training that it is simply a matter of drawing the farther objects proportionately smaller. It is called the use of perspective in drawing, where parallel lines appear to be meeting at a point on the horizon called the *vanishing point*. Anybody who has drawn a row of houses in their childhood knows that it is perhaps the most straightforward rule to identify and follow with respect to drawing.

However, studying the history of art reveals something astonishing: It was not until the 15th century that artists even discovered this rule, which until then had applied rough approximations of sizes in order to achieve the 3-dimensional effect. For millennia, *the*



Albrecht Dürer, *Instruction How to Measure with Compass and Straight Edge* (1525)

mathematical laws of perspective were unknown.

In fact, once discovered, a machine with strings and weights was utilized for implementing this technique as shown in the image below.

Numerous descriptions of perspective in art and Renaissance art include these technical descriptions, but an important question is missed. How is this enormous discrepancy possible, in something as “normal” as watching train tracks or road lines meeting at a vanishing point? Even though geometry of lines had been known and well-studied for millennia, why did one have to wait until the 15th century for artists to catch on to something that even a young child, with his eyes open, can identify? This is one question to keep in mind, as it prevents a projection of today’s ideas backwards indiscriminately, and shows that entirely different points of view (literally) existed in different time periods.

Just as worldviews change, the thinking process also changes along with it, and so it is necessary to know how thought evolved—or how it was constructed over a period of time. This change in thought process over time can be tackled by observing how the change occurs in an everyday situation. For example, consider a scenario in which a logical mathematical proof is being taught to students: The solution to quadratic equations gives two roots. Even with adult students, it is clear from the learning process that there is a big difference in solving equations before and after proving this rule. Seeing something solved is different from solving it oneself. Something that appears insurmountable previously appears easy, straightforward and logical after learning it. Similarly, mathematical rules taught in high schools today required, in the past, the best minds in mathematics to design and identify them; they had to be formulated, or constructed, for the *first* time.

In these examples there is a lot more to the thinking process than mere logic, the same concept that was earlier hinted as “inner effort.” This defines the difference between something

that has been discovered already and something that has to be discovered anew. It also shows that discovery is by no means a simple process of logical extension, or many of these discoveries would have been as straightforward as drawing two straight lines to identify where they intersect. Observing numerous instances of the thinking and learning processes in people can confirm that there is a significant difference before and after a thought structure has been built up.

Before the construction of a logical sequence, effort of will is paramount, while after its construction, one can simply observe the process and find it to be logical.

We will identify this process of inner effort as “willing,” which is something joined to the activity of “thinking.” It must be emphasized that these concepts are not arrived at in a theoretical fashion, but directly from the observation of the thinking process itself, something that every thinking person can verify from experience. An objection can be raised that this element of internal effort might not be real, but just a figment of imagination caused by the situation. However, the criteria being used to determine its validity is the same as that used by logic: an internal observation of truth and its external verification. As long as it can be verified that there is a difference between memorizing a concept and understanding a concept, this fact of internal effort stands on solid ground. Just as the builders of a mansion must spend an enormous amount of physical effort in constructing all the staircases and interconnected rooms, which the occupiers can then simply walk over, in the same fashion the structures of thought built by the great thinkers of one era are simply “walked over” by their descendants. If thinking were a matter of logical/intellectual connections alone, then it would be as simple to *make* a road as to *walk* on it. Reality shows otherwise; there is a

large difference between the two. The factor that comes into play beyond logic is *effort*, or *will*.

However, application of effort and knowledge of logic are necessary but not really sufficient in order to lay down the pathway from one idea to another. Continuing the analogy of construction, consider a railroad builder who cannot see past a mountain. In other words, he knows the laws of mechanics enough to dig a tunnel and he has the necessary manpower to get the job done;

however, whether the job can really be accomplished or not cannot be determined with only these conditions. Something else more mysterious comes into play: *skill* or *feeling*. Whether gained from long experience or due to innate talent and genius, this realm of feeling is that from which the mysterious nature of *skill* manifests itself and actually completes the entire process.

In the example above, a skilled builder would have developed a *feel* for the terrain (please note that the word is used here in a different sense from that denoting emotions alone) that would indicate whether or not the task can be done in a satisfactory way. This same skill is observed by mathematicians and engineers as well, who speak of the beauty of certain theorems and the artful way in which proofs or even machines are constructed. Thus, while the thinking process might superficially appear to be a straightforward matter of connecting one concept to another logically, the actual process is similar to the building of a cathedral. Laying one brick on another does not a cathedral make. A complete idea of the entire building (the layout), the effort necessary to build it (the manpower), and the artistic flourish that gives each cathedral its individual stamp (skill of the workers) are all necessary for the structure to stand and function.

These are hence the distinctions within the process of thinking: thinking itself, thinking

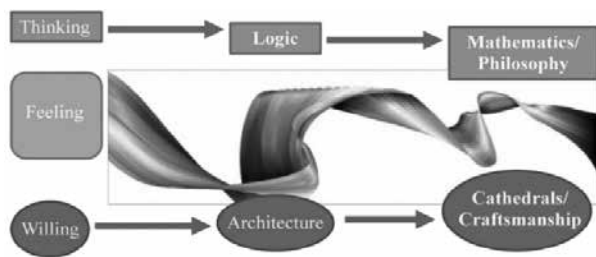
What this means is that just as worldviews change, thinking process also changes along with it, and it is hence necessary to know how thought evolved, or how it was constructed over a period of time.



colored by willing (inner effort), and thinking colored by feeling (individual skill). Just as the strength of a building lies in its framework, and the strength of a limb is determined by the skeletal bones, the strength of a thought process lies in how well it stands up to scrutiny and verification, i.e., how it leads to a better understanding of the world. When there are inconsistencies within a structure, it has the same effect as that of a broken pillar, which cannot support the building any more. This is why it was necessary for the most vigorous efforts to be applied by many individuals in order to create a theory or a philosophy, as the thought framework had to be built. An individual who works on developing this internally consistent thought structure can be called the *Philosopher*.

This differentiation of the thinking process also sheds light on a different approach in the development of civilization. Just as it was observed that thinking involved a feeling or nuance and also inner effort or willing, the same can be observed in the actual physical toil: the domain of willing. Someone who spends the entire day working at a construction while obeying the orders of an architect can be described as living in the action or willing alone. However, when the construction worker not only piles stone upon stone, but also has a say in the design underlying the construction, the element of thinking enters into the physical actions, which ultimately leads to the development of skill. Instead of starting with the concept or idea, this person transforms things by starting with actual building experience. This individual can be called the *Craftsman*.

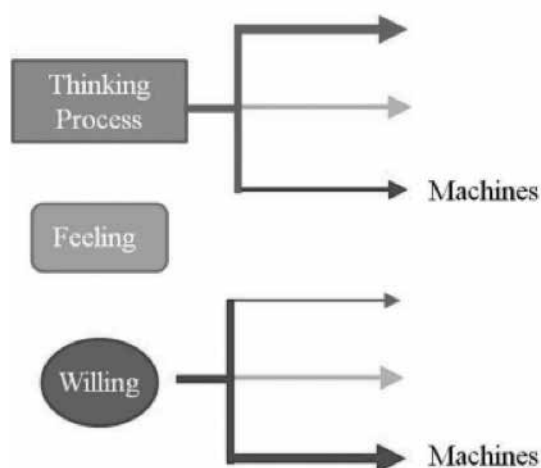
The Philosopher and the Craftsman are thus the essential actors on the world stage, with the Artisan or Artist serving as a mediator between them. A Philosopher begins with thinking and merges the other aspects into it. The Craftsman begins with something tangible, with the actual building process, and merges the other aspects into this activity. They both utilize skill: an artistic Philosopher sculpts one thought to another with the same skill that an artistic Craftsman brings to the buildings. The Artisan is hence active in both the approaches. Thus, thinking, feeling, and willing are observed to be concepts which intermingle with one another, and whichever is dominant generates the mode of activity. These two parallel streams, one which took the route of philosophy and the development of thought structures (Philosopher), and the other which dealt with the building of devices, cathedrals, and temples (Craftsman), ran parallel for several centuries, with some mediation from art. One culminated in the knowledge of mathematics, while the other in practical expertise of architecture and technology. The threefold nature can be represented thus:



After the Renaissance, the two streams of Philosopher and Craftsman started merging, from which “offspring” resulted: Natural Science, Physics, Technology. Thinking and willing merged together gradually, creating new machines.

The three divisions illustrated above are not airtight boxes, but they indicate the biases within the activity of man. There is hence an overlap of each quality with the other two, i.e., thinking has aspects of feeling and willing, willing has aspects of thinking and feeling, and so forth. Since it is the element of physical toil, i.e., the *external*

effort or physical will that gets outsourced to the machines, a similar process is to be expected for the thinking process too: the *internal effort* of thought (the will-element of thought) is likely to be outsourced to the calculating machines. This distribution can be indicated like this:



The aspect of feeling contributes to both extremes, and for the purpose of understanding the extremes better, it is kept aside for the time being. Both thought and physical action have the potential of getting outsourced. Just as various tools and devices help by multiplying the physical effort of man, there is an element of inner effort that machines, when suitably designed, may multiply as well. This was the situation at the end of the 17th century Enlightenment era when the first “aids to thought” were being constructed.

While the differentiations of thought into the willing and feeling element were perhaps not addressed clearly, thought was still not restricted to a mechanical process in this time period. Other aspects of thought life were still seen, and in fact, the ethical motivation for will power was still very clearly emphasized. For example:

I found it appropriate to insist a bit on these considerations of final causes, incorporeal natures and an intelligent cause with respect to bodies, in order to show their use even in physics and mathematics: on the one hand, to purge the mechanical philosophy of the

impiety with which it is charged and, on the other hand, to elevate the minds of our philosophers from material considerations alone to nobler meditations. (Leibniz, *Discourse on Metaphysics*, 1686)

The lives of many philosophers and mathematicians of this era were also steeped in both arts and devotional religious works (feeling and willing), which are generally discounted as irrelevant or mistaken by modern scientific researchers. For example, Newton considered his theological works to be of more importance than his scientific ones. Leonhard Euler, one of the most prolific mathematicians of all time, wrote the *Defense of the Divine Revelation against the Objections of the Freethinkers*. Blaise Pascal, discoverer of projective geometry and child prodigy in mathematics, underwent a religious conversion when he was 31 and produced works on theology. Leonardo Da Vinci is the epitome of the Artist-Craftsman, whose feats are perhaps unparalleled by any individual today.

Modern research has great difficulty in accepting that there is more to the thinking process than is commonly believed today and is especially confused with the firing of inner effort by religion. The following passage shows this clearly:

This combination of fanatical devotion and original scientific thinking was not uncommon during the period. And such obsessive faith was no self-protective affectations of genius either. Van Helmont, Pascal, Spinoza, and Newton all considered that their religious thought was their major contribution. A curious aberration... (P. Strathern, *Mendeleyev's Dream*, 2000, p. 171)

It is neither a curious aberration nor a weird obsession, but a necessary component of the complete thinking process. It is straightforward evidence of the fact that the inspiration for inner effort—the will element—has a major role to play in the production of mathematical and

philosophical works. The feeling element as well as the inner effort enhance external construction by multiplying the physical effort of man. There is an element of inner effort that machines, when suitably designed, may help complete the thought process. A study of the lives of scientists reveals this working together of the Philosopher and the Craftsman to various degrees. It also reveals mistakes in thought processes clearly through their life experiences. For example, Francis Bacon has had an enormous influence on the experimental method followed in the past two centuries, and his method of coming to generalities by way of individual instances has become famous as the Inductive Method in science. His writings on *The New Atlantis* and his descriptions of Solomon House inspired the foundation of the Royal Society. Yet, in spite of all the descriptions of experimental methods to be followed, the only experiment that Bacon ever carried out himself had ironic, unexpected results: Wondering if flesh can be preserved by refrigeration, he got out of his carriage in the snow, borrowed a chicken, and stuffed it with snow—a feat that led to an infection of pneumonia and death barely two weeks later. Once more, it shows the fallacy in the philosophy that neglects the thinking capacity of the human being and emphasizes exclusively the repetitive experimentation. The willing element of thinking, especially that relates only to repetition, dominates everything else and, hence, leads to a dead end.

However, with the introduction of the first calculators, this inner effort of repetitive thinking was outsourced to a mechanical device. Just as huge engines multiplied the efforts of men in industry, the possibility of multiplying calculating capacities also arose. Hence, the thinking process does contain an element that involves effort, and all repetitive effort can be outsourced to a machine.

The Philosopher and the Craftsman are thus the essential actors on the world stage, with the Artisan or Artist serving as a mediator between them.

This does not exhaust all that thinking can accomplish in the world. This is how the question posed at the beginning of this article can be answered: Thinking is not identical to a mechanism, but does contain elements which can be mechanized. That is the crucial idea.

As the streams of the Philosopher and the Craftsman intersected one another, several philosophical issues arose regarding the free will of man, his thoughts, and his relationship to machines. The first time the streams intersected, it gave rise to the works of Leibniz and Pascal in the area of “thinking machines” and the work of Newton in the area of natural science. After this era of Enlightenment, the streams diverged slightly for another two hundred years, when both the Philosopher and the Craftsman worked more in their own domains. The 200-year gap was filled with the discovery of numerous technological devices, and philosophy took the center stage in most of Europe of the time. When the two streams intermixed again in the second half of the 19th century, they gave rise to the field of mathematical logic for the Philosopher and that of numerous calculating machines for the Craftsman. These subjects need to be studied further, to illuminate the transformation of the thought process over the next two centuries.

[to be continued in the next issue of
the *Research Bulletin*]

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It is difficult to find a domain of human experience that has not been affected, altered, or augmented by digital technology. From commerce and the pursuit of science, to entertainment and everyday tasks, devices built on digital technology now constitute the most prevalent means for working in the world.

But what is digital technology? How do the concepts signified by the word *digital* serve as the basis for the computer that I am now typing on? In this first article in a series of three, I will explore the historical origins of digital technology and how a few relatively simple concepts have led to the development of tools of an ever-increasing level of sophistication. By bringing the ideas that are at the center of digital technology into sharper focus, it is my hope that a kind of “digital gesture” will reveal itself, a gesture whose attributes remain remarkably consistent against a seemingly bewildering avalanche of new innovations. Subsequent articles will explore some of the more subtle ramifications of the digital revolution¹ as well as recent developments—including virtual and augmented reality (Pokémon Go anyone?)—with potentially far-reaching implications for the future of human consciousness.

Whence digital?

In the 17th century, long before the word “digital” came to be associated with modern technology, the word “digit” became an English word referring to the divisions at the end of a limb (a finger or toe) or to the individual, discrete units of a numeral system (e.g., the numerals

0–9).² Both of these meanings open perspectives from which the digital gesture may be glimpsed.

Consider the significance of how individual digits—fingers—can be moved and brought into a specific form while gesturing with the hand. The configuration of one’s digits could be understood by an onlooker as an invitation, a warning, or an insult, depending on the observer’s cultural background. A hand gesture composed of digits is a sign or symbol capable of conveying something that may be living in one’s inner life out into the world.

Conversely, the language of hand gestures and the dexterous use of tools have played a pivotal role in how human beings have come to develop worldly intelligence. In the remarkable book *The Hand*, neurologist Frank Wilson uses the heading “hand-thought-language nexus” for a chapter exploring the close relationship between the human hand and brain and the evolution of an intelligence that has allowed humanity to gain “dominion over the rest of the natural world.” So much for one type of digital intelligence.

The second meaning of the word *digit* refers not to mobile appendages but to mathematical concepts. In the context of mathematics, however, the word loses most of its cultural significance and refers to the most basic form of representation within a numeral system. Most people are familiar with the numeral system called base 10 (also known as the decimal system) even if the term itself is unfamiliar. In base 10—which has ten discrete digits associated with it: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9—any number over nine is represented by more than one digit

The language of hand gestures and the dexterous use of tools have played a pivotal role in how human beings have come to develop worldly intelligence.

(e.g., the number forty-nine has two digits: 4 and 9).

But, despite its seeming ubiquity, base 10 is only one of a wide range of numeral systems. Some cultures, for example, use base 12 as the basis for their system of counting.³ The signature of what has come to be known as digital technology is written in the numeral system with the least possible number of digits, namely, base 2, otherwise known as binary. In binary the digits 0 and 1 suffice to represent any number. And, unlike the intelligence developed through the movements made by human digits, the digits of binary represent an entirely different variety of intelligence, an intelligence independent of any external movement.

The birth of binary

Around the same time as the word “digit” crept into the English language, the concept of binary was dawning in more than one English mind. Although the binary system was first defined as such by Gottfried Leibniz in 1679, it was already substantially established 74 years earlier by Francis Bacon of Verulam in what has come to be known as Bacon’s Cipher.⁴ Conceived as a method for encrypting any kind of communication, the cipher allowed for the open transmission of a coded message whose meaning remained concealed to anyone lacking knowledge of the pattern behind the encoding.

The intrinsic simplicity of the scheme allowed any message that could be put into language to be conveyed through nearly any means or apparatus. (Although tedious in actual execution, a lantern or bell would suffice to convey an encoded message.) Concealment and a claim to universality are both hallmarks of the digital gesture, attributes that characterize equally well the paradox at the center of Bacon’s life. As part of the courtly machinations of his time,

Bacon, like Machiavelli before him, recognized the need for secrecy, guile, and “serpentine wisdom.” On the other hand, Bacon also aspired to discover a “universal key” to the laws of nature and considered not less than “all knowledge” to be within his domain of research. He laid great emphasis in his writings on the need for a “universal language” that could be based on “signs.” He writes that

...whatever can be *divided into differences sufficiently numerous* to explain the variety of notions...may be made a vehicle to convey the thoughts of one man to another.⁵ [emphasis added]

Two hundred years after Leibniz codified base 2 into a formal mathematical system, effectively through a merger of arithmetic and logic (true=1; false=0), George Boole provided the mathematics necessary for making binary calculations. Then, a mere one hundred years after the establishment of “Boolean algebra,” and closely following

Turing’s description of a Universal Machine,⁶ the invention of the silicon-based transistor in 1954 opened the door to the type of electronic machine calculation that remains the basis for every digital device produced today.⁷

Due to the steady, decades-long stream of innovations predictably following Moore’s Law,⁸ a modern computer’s central processing unit may now contain over seven billion transistors. Yet, despite their astronomical numbers and miniscule size, individual transistors in any digital circuit amount to what they were the day they were invented: on/off switches unrelentant on a human digit for their actuation.

But where are the ones and zeros?

Behind WiFi, video games, virtual reality, the Internet, GPS, self-driving cars, and all other machines based on digital technology, there must

[T]he digits of binary represent an entirely different variety of intelligence, an intelligence independent of any external movement.

exist, inevitably, a series of representations of the concept “one” and the concept “zero.” No matter how complicated, every digital device ultimately requires access to at least one such series of representations. Hidden from view on the hard drive in your computer, in the Cloud, on music CDs, or the memory card in your cellphone, a representation of a sequence of ones and zeros must exist somewhere in some form of media.

A music CD can serve as a representative example. The shiny, reflective side of a typical music CD consists of a single spiral track—too small to be seen with the naked eye—that begins near the center hole and ends toward the outside edge of the disc. If this spiral would be unwound into a straight line, it would measure more than three miles long. Impressed throughout the length of this spiral track are tiny indentations called “pits” that are interspersed with areas containing no indentations called “lands.” The transitions from pit to land and from land to pit represent “one” and areas of no transition represent “zero.” As the disc spins, a laser shines onto a single point that tracks along the spiral’s axis, and the reflections cast by the passing pits and lands are progressively “read” by a light-sensitive detector. The series of ones and zeroes then undergoes a number of mathematical operations in order to create an electrical signal capable of driving a speaker.

A nearly identical process, only in reverse, created the pits and lands on the CD in the first place: a microphone—which is, basically, a speaker wired backwards—translates the movements of the surrounding air into an

electrical signal; the signal is subjected to a series of mathematical operations; the results are stored in memory as a series of ones and zeros; a representation of the series is stamped or progressively burned via laser into the spiral of a blank CD.

Creating a representative series of ones and zeroes—called digital data—requires certain information to be extracted or “digitized” from some detectable phenomenon, a phenomenon that is otherwise experienced as continuous with other surrounding phenomena. Such a process occurs, for instance, when a digital image is recorded by a digital camera.

Imagine gazing at distant mountain peaks set against a bright sky. Now hold before your mind’s eye a grid or net so that the image beyond is framed by each delineated hole of the net. By numbering each hole of the net in sequence and noting if the image in each hole is light (sky) or dark (mountain), you have effectively digitized the view, albeit at a very

low resolution. You could now produce a digital image by filling a piece of graph paper having a number of squares equal to the original net with the data from the digitization process.

As the “size” of the holes in the net decreases, the resolution of the resulting image increases. The camera in the average smartphone is capable of digitizing from its

3264 x 2448 “holes” enough data to produce an image of “photo quality.” Regardless of the context, each instance of digitization—one could also call it discretization—results in exactly the same outcome: A series of ones and zeros comes to be represented in some medium, physically, magnetically, or otherwise.

[D]espite their astronomical numbers and miniscule size, individual transistors in any digital circuit amount to what they were the day they were invented: on/off switches unreliant on a human digit for their actuation.

By numbering each hole of the net in sequence and noting if the image in each hole is light (sky) or dark (mountain), you have effectively digitized the view, albeit at a very low resolution.

A clock that binds, not unwinds

Having answered the *where* of digital data, the question of *when* remains. How digital data becomes useful again once it has been frozen somewhere ("saved"), touches on a theme at the very core of digital technology: the clock. Before any digital device can begin reading, processing, or producing ones and zeroes, there must be some method of separating one moment from the next so that one calculation can follow another in an orderly fashion. Since a machine is not able to execute an operation outside the programming to which it has access, once it is powered on, it must follow a protocol or set of instructions: If this, then that, otherwise do something else. But everything can't happen at once.

For this reason, each digital device requires some way of "keeping time." It is here that the digital gesture finds its most apt expression, for a digital clock is not something that ticks, trickles sand, or tracks the sun, but is, rather, a shard of quartz made to vibrate at a fantastic frequency. Certain properties of shape combined with the piezoelectric effect make it possible for a quartz crystal to generate an electrical signal that oscillates between the states "on" and "off." Back in the ancient 1990s, a reference to the vibrational frequency of the crystal in a computer's main processing unit was used as a kind of shorthand for the overall speed of its calculating capability. In terms of speed, the edge of what was then considered to be the state of the art moved from hertz to megahertz to gigahertz.

This last designation is reserved for any chip whose clock speed exceeds one billion vibrations per second. With each on/off cycle of the clock, a simple mathematical operation can be made:

Since a machine is not able to execute an operation outside the programming to which it has access, ... it must follow a protocol or set of instructions: If this, then that, otherwise do something else.

Time is now ... synonymous with an oscillation between two discrete, fixed poles. It has itself been digitized.

adding together one and zero, for instance. That is not particularly useful. But when billions of transistors are driven to produce billions of calculations billions of times each second, an astonishing world of possibilities opens up. It is the blinding speed of sequential calculation that makes every manifestation of digital technology possible.

It is a feature of the digital gesture that it works back onto the world conception that produced it in the first place. The Standard International unit of time defines one second as the period that elapses during "9,192,631,770 cycles of the radiation produced by the transition between two levels of the cesium 133 atom." Atomic clocks based on this definition now gain or lose one second in fifteen billion years, a timeframe that eclipses by more than one billion years the age of the known universe as proposed by the Big Bang theory. Time is now, by definition, synonymous with an oscillation between two discrete, fixed poles. It has itself been digitized.

Digital idol

As the digital gesture facilitates devices that are ever-smaller and more compact while simultaneously allowing for an ever-increasing speed of calculation, what becomes of the data produced, stored, and processed via these capacities? What happens to all the digitized libraries, discographies, maps, images, financial information, et cetera ad infinitum, that comprise the ever-expanding trove of an era already long under the influence of Big

Data? Sophisticated algorithms make it possible to discern apparently meaningful patterns within the worlds of data that have been built out of binary "atoms," the seemingly endless

representations of ones and zeros. But, what do such representations amount to outside the digital realm?

Before considering the relative merit of the binary representation of something, at least three assumptions must be made. First, that sufficient data corresponding to the “something” can be captured in the first place. (How many pixels does one need to be able to recognize one’s mother in a digital photo?) Second, that there is a mechanism by which the data can be reconstituted or “read” in the future. (What happens when a long-forgotten CD containing family photos resurfaces in a world that no longer contains a corresponding CD reader?) Third, that the recovered data can be displayed or otherwise reproduced in some meaningful way. (Of what use is the data read successfully from a CD if it produces “pixel” information for a display that can reproduce only “polygon” information?) It is possibly an example of poetic justice that the binary system, as implemented in digital technology—to all appearances capable of representing some version of reality in the most objective, unbiased, quantitative manner yet conceived—is useless without the layers of context by which it can be interpreted. Just as a language cannot be truly meaningful without someone who is able to speak and understand it, a string of 1s and 0s is inherently meaningless without a machine capable of recontextualizing it.

From this point of view, binary data, no matter how well it is outwardly represented, can only ever be an artificially produced image of something else. The digital gesture, shrouded by the binary data that it produces, closely resembles what Owen Barfield refers to as an idol. He asserts that, “when the nature and limitations of artificial images are forgotten, they become idols.” (Barfield 1988, p. 39) When seeing an image on a computer monitor or reading an email or hearing a voice through a cell phone, it is very difficult to keep in mind that each of these is an artificial image that is necessarily limited by the very data that comprises it. The Psalmist,

in describing the creations of forgetful idolaters, puts it this way:

*Their idols are silver and gold:
even the work of men’s hands.
They have mouths, and speak not:
eyes have they, and see not.
They have ears, and hear not:
noses have they, and smell not.
They have hands, and handle not:
feet have they, and walk not:
neither speak they through their throat.*

Building a better batoid (any cartilaginous fish in the superorder *Batoidea*)

Despite being haunted by the spectre of an overwhelming number of artificial images, digital technology taken as a whole constitutes the most powerful instrument that modern civilization has been able to produce. A paper recently published in the journal *Science* documents the real-world efficacy of the digital gesture. A diverse group of researchers working across several scientific domains was able to create a 1:10 scale artificial skate with a skeleton of gold capable of swimming using muscle cells grown from rat heart tissue genetically engineered to react to specific frequencies of light.

After pausing to admire the sheer audacity of such a feat, one might initially struggle to identify ways in which digital technology as such played any role in the development of this “living, biohybrid system.” But, as the dazzling effect of scientific heroism fades, the digital gesture lying behind each idea and piece of equipment used to construct such an animal-machine becomes apparent. To micro-fabricate the gold skeleton, genetically engineer the light-sensitive muscle using a technique to precisely “edit” DNA, and even to record and present the images of the finished project, each step required the use of digitally-derived tools.

The coordination of the diverse international team also required the use of digital

communication technology, as did access to digital archives and the experimental data of other relevant projects. Despite any appearances to the contrary, the digital gesture is the foundation for all such technical virtuosity. It is perhaps due only to the circumstance of many of these techniques and technologies having already become passé that they do not shine out as brightly to one's attention as does a shimmering skeleton of gold.

Mind the meme

No essential criticism can be leveled against the digital gesture in and of itself. It has enabled the sublime technical prowess lying behind all the relatively recent advances that have quickly come to be merely mundane for the most privileged parts of the world: celebrity-voiced driving assistants, personalized online shopping services, and an unwatchable number of digital media outlets, to name a choice few. Failing to keep the digital gesture firmly in one's consciousness, however, can lead to the acceptance of each new technological wonder as if it were inevitable, unavoidable, and hopelessly beyond one's ken, a magical happening created by way of a sufficiently advanced technicity.

That the digital gesture is equal to the task of producing novel forms of life is an established fact. That the artificial lifeforms in question owe their existence to a flickering sea of artificial images is easily forgotten. The entire digital world is reminiscent of a mode of observation characterized by Ernst Lehrs as the "one-eyed color-blind approach." Should we, like Odysseus, hope to escape from the cave of a monochromatic, one-sided world outlook, it seems likely that such an endeavor will require the courage to forego the exclusive use of a correspondingly one-sided intelligence, no matter how powerful it may appear.

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ENDNOTES

1. The industrial revolution that began in the late nineteenth century gave way to the digital revolution in the late 1950s, an impulse that continued to develop significantly in the 1960s and 1970s. Today in 2016, the fruits of the digital revolution have become central to a way of life in many parts of the world, and the use of digital technologies is now considered essential in almost every industry. (See the excellent 2013 study "Embracing Digital Technology" by MIT Sloan Management Review.)
2. The word *numeral* refers to an individual element in a system (e.g., "2") while the word *number* refers to the concept that is represented by the numeral (the idea of "two of something" or "twoness"). The words "numeral" and "digit" are not synonyms in the mathematical sense. A digit is always considered to be discrete, relating to a single element, whereas a numeral can refer to a number represented by several digits. For example, the concept "one hundred and two" can be represented by the numeral 102 which consists of the digits 1, 0, and 2.
3. Base 12 or the duodecimal system has twelve representative digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, T, and E where T and E represent the equivalent of 10 and 11 in base 10. This means that base 12 can represent with one digit (e.g., the digit "E") what would take two digits in base 10 (i.e., "11"). Following the pattern further, the number twelve in base 12 is written as 10 and one gross—one hundred forty-four—as 100! There are several organizations that advocate for the general adoption of the duodecimal system as a replacement for base 10 due to the former's many advantages, the most significant of which is the ease with which fractions can be calculated (not to mention 12 signs of the zodiac, 12 months of the year, 12 hours of the clock, 12 finger bones of the hand, etc.).
4. Bacon's Cipher is a system of encryption whereby each letter of the alphabet is replaced by the characters "a" and "b," arranged in particular sequences. The letter "A," for instance, would be represented by the sequence "aaaaa," the letter "B" by "aaaab," "C" by "aaaba," and so on through to "Z" which would be "babbb." (In attempting to reconstruct the other letter sequences, particularly inquisitive readers may find themselves wondering

why “Z” isn’t represented by the sequence “bbaab.” Answer: The alphabet of Bacon’s time consisted of only twenty-four letters.) This cipher was the precursor for what would later become the pattern for representing numbers in binary, with “1” and “0” replacing the characters “a” and “b.”

5. “The Advancement of Learning,” Book VI, *The Works of Francis Bacon*. James Spedding, Robert Ellis & Douglas Heath, eds., London, 1901, p. 439.
6. Alan Turing, famous for having helped to break German ciphers in World War II, was first to realize that it was “possible to invent a single machine which can be used to compute any computable sequence.” This possibility—which he called a “universal machine”—laid much of the theoretical groundwork for the initial developments of computer science.
7. A transistor is simply the electronic version of a light switch: It either lets electricity flow or it doesn’t. The switching of a transistor between its on and off states is controlled by electricity. By connecting transistors together in various arrangements, the resulting electronic circuits can be made to produce results that are consistent with Boolean algebra. All digital logic is built from these basic circuits.
8. Moore’s Law, named after Intel co-founder Gordon Moore, predicts that the number of transistors that can fit into a square inch will double every 18 months. It is no exaggeration to say that faith in Moore’s Law has fundamentally driven the digital revolution by allowing software and hardware companies to successfully plan well into the foreseeable future.

REFERENCES

- Bacon, F. (1605). *The advancement of learning*, Books II and VI.
- Barfield, O. (1988). *Saving the appearances: A study in idolatry*. Wesleyan University Press.
- Fitzgerald, M., et al. (2013). “Embracing digital technology: A new strategic imperative.” *MIT Sloan Management Review* 55.2:1.
- Lehrs, E. (1985). *Man or matter*. Rudolf Steiner Press.
- Park, S., et al. (2016). “Phototactic guidance of a tissue-engineered soft-robotic ray.” *Science*, 353(6295), 158–162.
- Wilson, F.R. (1999). *The hand: How its use shapes the brain, language, and human culture*. Vintage.

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Children, Technology, and Nature Awareness

George K. Russell

The fact that children are spending less and less time in nature—and some not at all—is not only a tragedy for individual children, but for the future of our species. For this contact is so important for psychological and spiritual development. When I think of my childhood, I remember spring bulbs pushing up pale shoots through the dead leaves, spiders in the garden carrying tiny babies on their backs, the scent of violets and honeysuckle, and the sound of the wind rustling the leaves as I perched for hours in the branches of my beech tree. It was that magic of childhood that shaped the passion that drives me to spend my life fighting to save and protect the last wild places on the planet.

— Jane Goodall, PhD, DBE,
UN Messenger of Peace

In July 2014 the Myrin Institute published an anthology of 12 essays under the title *Children and Nature: Making Connections*. As a contributor and editor of this collection, I hoped the book would find its way into many hands because of what I perceived as a profound disconnect between young (and not so young) people and the world of nature. I had come to see the widespread immersion by so many into a world of hand-held devices, computer games, and digital images as a basic form of addiction,

a behavior leaving little time for regard or attention to what is real, especially phenomena of the living world. And as a teacher of biology undergraduates for many years, I gradually found it mistaken to expect that young students of biology would come to university with a thorough background and understanding of natural history or an acquaintance with the basic biology of plant and animal life out of direct personal experience.

Several important works came to my attention. Richard Louv's *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder* concluded that children no longer play out-of-doors – those who do are a kind of endangered species. The Kaiser Foundation survey in 2010 found that the average American child spends almost eight hours on a screen each and every day. (Today's statistics are surely higher.) And more recent studies, although anecdotal, suggest that many young people cannot identify or characterize common flowers, song birds, or local animals. Within this context it seemed essential to collect a series of essays that would assist others—parents, teachers, environmental educators, young people themselves—in addressing a fundamental existential challenge.

From these reflections came *Children and Nature: Making Connections* and the question, "How can we help young people form living connections with the natural world?" The aim, above all, was the matter of connections—direct experience of the living world, practical hands-on projects in nature, gardening, and working with animals, literature, and the arts, and more. As I hope this essay will show, the consequences of "nature deficit disorder" for young people and for the world we live in, especially the natural world, can only be described as dire.

This essay is adapted from my introductory segment in *Children and Nature: Making Connections* (2014, The Myrin Institute, Great Barrington, MA 01230). This book is available from Myrin at www.myrin.org or through amazon.com. All quoted passages, except as otherwise noted, are drawn from essays in *Children and Nature*. Passages from *The Sense of Wonder* are under copyright protection © 1956 by Rachel L. Carson and are reprinted with permission.

In my many years of university-level biology teaching, I regularly met young people whose chief interest was the study of cellular and molecular processes, but who had little acquaintance with living nature and little or no inclination to study the life sciences in a more holistic manner. There were always exceptions, and our departmental course offerings in ecology, vertebrate zoology, and animal behavior regularly attracted students with interests in field-based studies and the biology of whole organisms. And I was always heartened to find an occasional student who had spent many years of childhood outside in nature or one who had once tended vegetable gardens and hatched butterflies. But my long experience with students concentrating in biology and a wide variety of non-majors was that many had little meaningful experience of the natural world. I am seriously troubled by what I came to see as a deep gulf between the interests and inclinations of so many young people and the living world.

At the heart of the matter is the notion that direct personal encounter with nature, and the attendant feelings of wonder and delight, form the basis of a genuine ethos for protection of the natural environment. We will honor and preserve what we have come to love and admire, and such feelings find their source in personal experience. But what of those for whom there is little or no connection with nature? Can we expect them to participate with enthusiasm in the search for solutions to the vast array of environmental problems confronting us? And are we losing sight of the idea that each person has the possibility of finding in the many wonders of nature an opportunity for self-renewal and inspiration?

The Kaiser Foundation survey in 2010 found that the average American child spends almost eight hours on a screen each and every day.

More recent surveys show that many young people in this country can identify numerous corporate logos but cannot name or describe even five species of songbirds, local animals, or common flowers.

My approach in teaching, whenever possible, was to introduce an admixture of natural history into my several courses, including definite assignments in the close observation of living nature in whatever ways I could arrange. We were not able to visit the rainforests of Amazonia or Yosemite National Park, but we made

ample use of local habitats, the university campus itself, and what the ecologist David Ehrenfeld has termed “the rainforests of home.” Whatever successes I had as a teacher convince me that students will take a deep interest in the study of the living world, both inside and beyond the classroom, if

they are guided to an authentic encounter with living plants and animals, natural settings, and the enchantments of life itself.

I soon discovered that concern for my own students had far broader implications. In 2010 a thorough and far-reaching study by the Kaiser Foundation reported that the typical young

person in this country (age 8 to 18) spends, on average, 7 hours 38 minutes each day on some sort of screen (hand-held, video, TV, etc.).¹ (The Director of Kaiser declared that this amounts to more than a full-time job!) This leaves no time for quiet immersion in a natural setting, no time to play in nature, no time to experience the tides or the vicissitudes of the weather, or the comings and goings of

wild animals, or the resurgence of life in the spring. Recent surveys show that many young people in this country can identify numerous corporate logos but cannot name or describe even five species of songbirds, local animals, or common flowers. And one recent study goes so far as to state that many youngsters spend as little as five or ten minutes each day observing

or attending to even the simplest of natural phenomena. I have known students who spend virtually no time at all in such activity and who appear to be largely estranged from nature.

The essays in *Children and Nature* were compiled with the aim of awakening in readers the wish to assist young people by showing them what lies outside their front door or in a local park or nearby woodland.

Then true nature experience would begin to replace what can increasingly be seen as a powerful form of addiction, a dependency on text messages, e-mails, videos, and a torrent of unreal, virtual images. In sum, a fundamental challenge stands before us: How can we wean young people from their devices and begin to address the malaise of a widespread indifference to nature?

A foundation stone of the effort is Richard Louv's seminal book, *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder* (2005), and the nationwide movement he has inaugurated and inspired. Louv asserts that profound nature experience is a "spiritual necessity" for the growing child, but that the youngster who plays outdoors, like the Florida panther and the whooping crane, has become a kind of endangered species, in his words the "last child in the woods." A fourth-grader in San Diego put the matter very succinctly: "I like to play indoors better 'cause that's where all the electrical outlets are." Richard Louv quotes the naturalist, Robert Michael Pyle, who asks poignantly: "What is the extinction of a condor to a child who has never seen a wren?" and Louv looks to the future with concern asking, "Where will the next generation of stewards come from?" Included in the anthology are Louv's thoughtful reflections following the publication of his book and the series of talks he has given to parent groups, teachers, outdoor educators, young people, and concerned citizens. The movement

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to which he has contributed so much is often referred to, appropriately, as "No Child Left Inside." *Last Child in the Woods* was published over ten years ago, and since then Louv has authored two more books, *Nature Principles* and *Vitamin N*. Each book, especially *Vitamin N*, provides numerous suggestions for ways to help children and their families make meaningful

connections, and I recommend to all parents and teachers that they consult the Children and Nature Network (www.childrenandnature.org) for edification and inspiration, and, above all, to gain assurance that there are hundreds if not thousands of grassroots groups in this country helping young people experience and work with the living environment.

My particular focus was and is to identify significant readings that highlight various elements of the issue and bring these to the attention of young people, concerned teachers, environment educators, parents, and all those who see the need for a vast change in the way we raise and educate our children. The articles offered in *Children and Nature* were tried and tested with university students, especially those who are about to enter the field of teaching, and I was pleased to find many individuals who, in full sympathy, recognized both the need and the challenge.

Lowell Monke, one of the contributors to *Children and Nature*, was a computer sciences teacher in the public school system of Des Moines, IA, for some years and subsequently taught prospective teachers as a member of the Department of Education at Wittenberg University in Ohio. His long experience as a teacher of computer sciences showed him both the value and the challenges of an increasingly computer-bound age. Monke has been a singular voice in showing that, for every positive argument put forward in favor of computers in schools, there is a hidden, unrecognized loss.

He argues that the digital screen cannot begin to simulate the direct experience of nature that Richard Louv reminds us is so essential for the proper growth and development of the child. “Children come to know a tree,” Monke writes, “by peeling its bark, climbing its branches, sitting under its shade, jumping into its piled-up leaves. Just as important, these firsthand experiences are enveloped by feelings and associations—muscles being used, sun warming the skin, blossoms scenting the air. The computer cannot even approximate any of this.” I note with delight that “The Human Touch” is reprinted in this issue of the *Research Bulletin*. To my mind, this piece should be required reading for parents, teachers, and all those who care for the future of children and the future of the natural world.

Personal experience lies at the very heart of the matter. Individuals who are fortunate enough as children to have had profound connections with all that nature offers—plants, animals, wild places, natural rhythms, the sky and weather, and much else—will have a firm foundation that can extend throughout their lives. Scott Russell Sanders’s moving account of his relation with his son speaks directly to this theme. In “Tokens of Mystery” Sanders writes that “if a child is to have an expansive and respectful vision of nature, there is no substitute for direct encounters with wildness. This means passing unprogrammed days and weeks in the mountains, the woods, the fields, beside rivers and oceans, territories where plants and beasts are the natives and we are the visitors.”

David Sobel, author of “Look, Don’t Touch: The Problem with Environmental Education,” has made numerous and substantial contributions to

the field; his study, *Beyond Ecophobia: Reclaiming the Heart of Nature Education*, is widely cited and admired. His other books and articles carrying themes relating to “place-based education” are well known. In “Look, Don’t Touch” he reminds us that childhood experience in nature is all-important in establishing lasting bonds between individuals and the natural world. He writes that

“[F]irsthand experiences are enveloped by feelings and associations – muscles being used, sun warming the skin, blossoms scenting the air. The computer cannot even approximate any of this.”

John Muir, E.O. Wilson, Aldo Leopold, and Rachel Carson all had “down-and-dirty experiences in childhood” that formed lifelong bonds with the earth and its creatures. Sobel tells us that “nature programs should invite children to make mud pies, climb trees, catch frogs, paint their faces with charcoal, get their hands dirty and their feet wet.” Too

much emphasis on concepts and the mechanical principles of nature, especially in the early years, does little to establish the sort of deep communion with nature to which he alludes. “Between the ages of six and twelve, learning about nature is less important than simply getting children out into nature.” A recent book by Sobel and several collaborators, *Nature Preschools*

“Between the ages of six and twelve, learning about nature is less important than simply getting children out into nature.”

and Forest Kindergartens: The Handbook for Outdoor Learning, highlights an effort, originating in Europe, to bring children into nature at very early ages; several schools in this country, especially the Forest Kindergarten at

the Waldorf School of Saratoga Springs, have achieved remarkable success.

The most powerful voice of all is that of Rachel Carson. She is best known for her seminal work, *Silent Spring*, a book that helped to launch the environmental movement in the early 1970s, but she is also the author of “The Sense of Wonder,” a lyrical essay she wrote a few years before her death in 1964. This article is

currently under copyright protection and could not be reprinted in the anthology, but I must urge readers to locate the work and judge its value for themselves.² “The Sense of Wonder” has been widely acclaimed as one of the great American nature essays; it deserves full attention from everyone concerned for the future of the natural environment and the future of our children.

Carson spent her summer vacations at a cabin retreat along the coast of southeastern Maine, where she found repose and the inner strength to confront powerful voices not wanting to hear her message about toxic chemicals and poisoning of the natural environment. In “The Sense of Wonder” she helps the reader both to recapture something of lost childhood and to reflect on the sense of wonder that each child brings into life as a kind of birthright. Readers of this essay will be profoundly affected, I think, and I trust that each will come to value even more the power of nature to awaken our hearts to its beauties and wonders. Rachel Carson has alerted us to what we are doing to the natural environment; she has also shown us how in nature we can find sustenance for the human spirit.

A child’s world is fresh and new and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood. If I had influence with the good fairy who is supposed to preside over the christening of all children, I should ask that her gift to each child in the world be a sense of wonder so indestructible that it would last throughout life, as an unfailing antidote against the boredom and disenchantments of later years, the sterile preoccupation with things that are artificial, the alienation from the sources of our strength.

One of the most troubling aspects of our theme is that children seem to have forgotten how to play. For many if not most American children “free play” no longer exists.

Surely we must pay far more attention to the role of parenting and the need for caring adults to foster compassion and love in children, especially during the formative years of early childhood. Pattiann Rogers writes in “Cradle” that “I cannot think of anything more important for the future of the earth than that we have loving, diligent mothers and fathers caring for our children...If children learn to act with compassion by being treated compassionately themselves, if they learn to love by being loved, to respect others by having received respect, to cooperate by being involved in cooperation, to keep their word by experiencing honesty, to protect others by having been protected themselves, how can we possibly overestimate the importance of children being nurtured by dependable parents who are capable of demonstrating such qualities? It is these qualities that will form the basis for all future decisions our children must make regarding their interactions with other people and with the natural world.”

One of the most troubling aspects of our theme is that children seem to have forgotten how to play. Stephanie Hanes writes in “Toddlers to Tweens” that for many if not most American children “free play” no longer exists. Youngsters are programmed and scheduled, tested and retested, given little or no recess time at school, and pressured to get ready for higher levels of education. They have little or no experience of the joys of wandering, the vagaries of fantasizing, or the simple pleasures of made-up games, unscheduled days, and the carefree delights of summer. Hanes writes that “children’s play is threatened, and kids—from toddlers to tweens—should be relearning to play. Roughhousing and fantasy feed development.” The matter of children’s play is a serious concern for parents, teachers, and child psychologists throughout this country. Many current books, popular magazines,

and academic studies attest to this concern, and readers will likely be able to suggest titles of their own. I offer Gary Paul Nabhan and Stephen Trimble's *The Geography of Childhood: Why Children Need Wild Places*; Susan Linn's *The Case for Make Believe: Saving Play in a Commercialized World*; Scott Sampson's *How to Raise a Wild Child*, and the highly relevant publications of the Alliance for Childhood. The issues underlying these accounts and many others must find their way into the heart of current educational discourse, and they deserve our closest attention.

Along a similar vein, "The Privilege of Gardening with Children" by Carolyn Jabs, an important inclusion in *Children and Nature*, speaks to the matter of children and the soil. Young people who cannot recognize various types of wild flowers, songbirds, or species of ornamental trees and shrubs will not have planted seeds, harvested vegetables, or picked apples. Jabs offers helpful, practical suggestions for how parents can guide youngsters in the planting of and caring for a garden. Most importantly, she informs us that "children have a deep and abiding interest in growing, perhaps because they are doing it themselves. They remind us, if we let them, that the point of gardening is not a perfect platoon of well-disciplined plants. Rather, it is the privilege of witnessing a miracle as simple, profound and unpredictable as growth itself."

Most of my direct acquaintance with primary and secondary education is through Waldorf schools, and I am aware that many have made gardening and, where possible, the care of animals an important part of the curriculum. Waldorf schools in Harlemville, NY; Kimberton, PA; Garden City, NY; Hadley, MA; and the Summerfield Waldorf School in California have each instituted exceptional programs in gardening, and there are others, equally important, that could be cited. I urge readers to examine the website description of the Summerfield curriculum where it is evident that most young students working their way through

the 12 years of this program will likely emerge as individuals deeply connected to and concerned for the well-being of the land and committed to its preservation (www.summerfieldws.org/the-farm/). Children who spin wool, collect cow-pies, and build compost piles in the lower school, plant and harvest vegetables, care for farm animals, and work with natural materials in middle school, and undertake projects in sustainability in high school will surely be different from young people educated to the ordinary standards of public education. (I am aware that there are important projects going on in various public schools around the country, and I have no wish to belittle these efforts, only to point out the value of what I have learned from Waldorf education.)

There are further considerations. Douglas Sloan, Emeritus Professor of Education at Teachers College, Columbia, writes that children's "simply being in nature is not enough. If nature is to nourish children, and they in turn are to protect and nourish it as adults, imaginative capacities for feeling and perception must be brought to birth in childhood. Here the influence of word, story, poem, and all the arts become of crucial importance. They work with nature in awakening imagination. The confidence and capacity to meet and care for life are called forth by an education suffused with the beauty and forces of life." In this spirit we included two articles in the anthology: James E. Higgins's "Words Full of Wonder," an essay on the value of children's literature and the influence of adults who share stories with a child, and Richard Lewis's piece on "A Wilderness of Thought: Childhood and the Poetic Imagination," a wonderful account of poetry and the children who write it.

It is beyond the scope of this article to explore the place of drama, poetry, and the arts in education, but the role of children's literature deserves further exploration and commentary. As a child I read a great deal and a favorite book was *The Curious Lobster* by Richard W. Hatch. The curious lobster's thoughtful musings and his

adventures with Mr. Badger and Mr. Bear have lived with me ever since childhood. The book has no environmental message, and it makes no plea for conservation or animal protection. It deals only with the life of Mr. Lobster, a fictional character I came to love, and to this day I cannot order lobster meals in restaurants. I wonder how many other books of childhood have helped to shape my attitude and a sense of respect and compassion for animal life.

My parents grew up in very different parts of the country: my mother in the Bronx, my father in rural North Dakota. But both were exposed to the same texts at some point in their schooling, the nature essays of John Burroughs. These short essays highlight and celebrate simple happenings in nature, implicitly inviting readers to explore and make observations of their own. And it is an educated guess that Anna Botsford Comstock's classic volume, the *Handbook of Nature Education*, and Thornton Burgess's *Bird Book for Children* may have influenced my parents' young lives.

Sara St. Antoine, herself an author of many splendid books for children, has been exploring the range of contemporary children's literature for some years, and her observations lead to important suggestions for young readers and the adults who guide them to appropriate selections. Noting a decline over the last two decades in children's books that simply portray natural places or animal life, she writes:

We didn't have a lot of books about environmental problems when I was a kid. The stories that really nurtured my connection to nature were simply ones where a landscape and its inhabitants came alive. I wanted to experience vicariously the wind on the prairie, the waves on the seas. I wanted to see what

badgers or lions looked like up close and contemplate their daily routines, their wild spirits. On some level, I'm not even sure these had to be real ecosystems and real species.³

St. Antoine's book suggestions for young adults include such works as *An Owl on Every Post* by Sanora Post, *The Red Pony* by John Steinbeck, *Winterdance* by Gary Paulsen, and *Lord of the Rings* by J.R.R. Tolkien. Early readers are directed to *Grasshopper on the Road* by

Arnold Lobel, *Henry and Mudge and the Starry Night* by Cynthia Rylant, and *Mouse and Mole: Fine Feathered Friends* by Herbert Yee. By her standard these books are as much a part of the corpus of environmental literature as any books directly treating environmental issues and those who deal with them. (My own list includes all of Beatrix Potter, the several books about Babar and Celeste, and my favorites, *Freddy the Pig* and *Uncle Wiggily*.)

I leave the final words for Rachel Carson who speaks to the major theme of this collection. When asked by parents how they can teach youngsters about the natural world when they themselves know so very little about it, her answer was the following:

If a child is to keep alive his inborn sense of wonder without any such gift from the fairies, he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in. Parents often have a sense of inadequacy when confronted on the one hand with the eager, sensitive mind of a child and on the other with a world of complex physical nature, inhabited by a life so various and unfamiliar that it seems hopeless to reduce it to order and knowledge. In a mood of self-defeat, they exclaim, "How can I possibly teach

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my child about nature--why, I don't even know one bird from another." I sincerely believe that for the child, and for the parent seeking to guide him, it is not half so important to know as to feel. If facts are the seeds that later produce knowledge and wisdom, then the emotions and years of early childhood are the time to prepare the soil. Once the emotions have been aroused—a sense of the beautiful; the excitement of the new and the unknown; a feeling of sympathy, pity, admiration or love—then we wish for knowledge about the object of our emotional response. Once found, it has lasting meaning. It is more important to pave the way for the child to want to know than to put him on a diet of facts he is not ready to assimilate.

Rachel Carson tells us that "those who dwell among the beauties and mysteries of the earth are never alone or weary of life." But what of those who have little or no contact with the natural world and for whom the beauties and mysteries of the earth have long since disappeared? And what of those youngsters whose lives revolve around cyberspace, technological devices, and virtual images to the exclusion of anything resembling genuine nature experience? Do we not owe it to our young people to address the lessons of these essays with all the determination and strength of will we can possibly bring to bear?

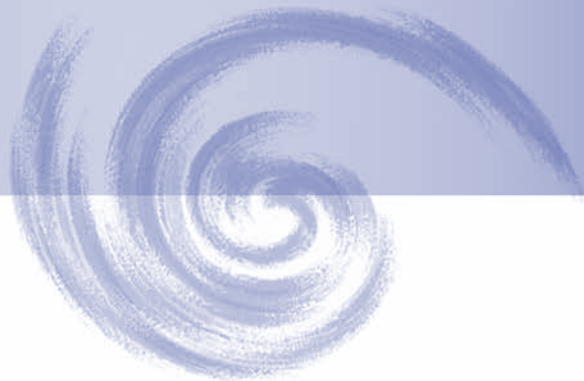
ENDNOTES

1. Generation M2: Media in the Lives of 8- to 18-Year Olds, a national large-scale survey conducted by the Kaiser Family Foundation, was released in January 2010. This survey found that the average "screen time" for young people in America was 7 hours 38 minutes each day or 53 hours per week, a figure markedly higher than a similar study done five years earlier. The complete report can be accessed at the Kaiser website, www.kff.org.
2. *The Sense of Wonder* is available from Harper-Collins in a splendid coffee-table format that includes Nick Kelsh's images of the Maine coastline and woodlands. The volume can be purchased through Amazon.com and is available also in Kindle format.
3. <https://www.childrenandnature.org/2013/12/07/the-nature-of-childrens-books-this-holiday-give-your-child-the-kind-of-book-that-will-inspire-a-love-of-the-outdoors/>

George K. Russell holds a doctorate in biology from Harvard University. His college level laboratory manual, *Investigations in Human Physiology* (Macmillan), shows how to teach biology without the killing of animals. As one of the co-founders of *Orion* magazine, he served as editor-in-chief from 1982–2002. Dr. Russell retired from Adelphi University in 2015 as Emeritus Professor of Biology after a long career in teaching and research. He also served as Board Chair of the Waldorf School of Garden City for 12 years.

The Human Touch

Lowell Monke



In the rush to place a computer on every desk, schools are neglecting intellectual creativity and personal growth.

In 1922 Thomas Edison proclaimed, “I believe the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks.” Thus began a long string of spectacularly wrong predictions regarding the capacity of various technologies to revolutionize education.

What betrayed Edison and his successors was an uncritical faith in technology itself. This faith has become a sort of ideology increasingly dominating K–12 education. In the past two decades, school systems, with generous financial and moral support from foundations and all levels of government, have made massive investments in computer technology and in creating “wired” schools. The goal is twofold: to provide children with the computer skills necessary to flourish in a high-tech world and to give them access to tools and information that will enhance their learning in subjects like mathematics and history.

However, in recent years a number of scholars have questioned the vast sums being devoted to educational technology. They rarely quibble with the need for children to learn how to use computers, but they find little evidence that making technology more available leads to higher student achievement in core subjects. As Stanford University professor Larry Cuban writes in *Oversold and Underused*, “There have been no advances (measured by higher

academic achievement of urban, suburban, or rural students) over the past decade that can be confidently attributed to broader access to computers. ... The link between test-score improvements and computer availability and use is even more contested.”

While it is important to examine the relationship between technology and learning, that debate often devolves into a tit-for-tat of dueling studies and anecdotes. The problem with framing the issue merely as a question of whether technology boosts test scores is that it fails to address the interaction between technology and the values learned in school. In short, we need to ask what kind of learning tends to take place with the computer and what kind gets left out.

The Need for Firsthand Experience

A computer can inundate a child with mountains of information. However, all of this

learning takes place the same way: through abstract symbols, decontextualized and cast on a two-dimensional screen. Contrast that with the way children come to know a tree: by peeling its bark, climbing its branches, sitting under its shade, jumping into its piled-up leaves. Just as important, these firsthand experiences are enveloped by feelings and associations: muscles being used, sun warming the skin, blossoms scenting the air. The computer

cannot even approximate any of this.

There is a huge qualitative difference between learning *about* something, which requires only information, and learning *from*

A computer can inundate a child with mountains of information. ... All of this learning takes place the same way: through abstract symbols, decontextualized, and cast on a two-dimensional screen.

something, which requires that the learner enter into a rich and complex relationship with the subject at hand. For smaller children especially, that relationship is as physical as it is mental. Rousseau pointed out long ago that the child's first and most important teacher is his hands. Every time I walk through a store with my sons and grow tired of saying, "Don't touch that!", I am reminded of Rousseau's wisdom.

What "Information Age" values tempt us to forget is that all of the information gushing through our electronic networks is abstract; that is, it is all representations, one or more symbolic steps removed from any concrete object or personal experience. Abstract information must somehow connect to a child's concrete experiences if it is to be meaningful. If there is little personal, concrete experience with which to connect, those abstractions become

inert bits of data, unlikely to mobilize genuine interest or to generate comprehension of the objects and ideas they represent. Furthermore, making meaning of new experiences, and the ideas that grow out of them, requires quiet contemplation. By pumping information at children at phenomenal speed, the computer short-circuits that process. As social critic Theodore Roszak states in *The Cult of Information*, "An excess of information may actually crowd out ideas, leaving the mind (young minds especially) distracted by sterile, disconnected facts, lost among the shapeless heaps of data."

This deluge of shapeless heaps of data caused the late social critic Marshall McLuhan to conclude that schools would have to become "recognized as civil defense against media fallout." McLuhan understood that the consumption and manipulation of symbolic, abstract information is not an adequate substitute for concrete, firsthand involvement

with objects, people, nature, and community, for it ignores the child's primary educational need—to make meaning out of experience.

Simulation's Limits

Of course, computers can simulate experience. However, one of the byproducts of these simulations is the replacement of values inherent in real experience with a different set of abstract values that are compatible with the technological ideology. For example, "Oregon Trail," a computer game that helps children simulate the exploration of the American frontier, teaches students that the pioneers' success in crossing the Great Plains depended most decisively on managing their resources. This is the message implicit in the game's structure, which asks students, in order to survive, to make a series of rational, calculated decisions based

on precise measurements of their resources. In other words, good pioneers were good accountants.

But this completely misses the deeper significance of this great American migration, which lies not in the computational capabilities of the pioneers but in their determination, courage, ingenuity, and faith as they overcame extreme conditions and their almost constant miscalculations. Because the computer cannot traffic in these deeply human

qualities, the resilient souls of the pioneers are absent from the simulation.

Here we encounter the ambiguity of technology: its propensity to promote certain qualities while sidelining others. McLuhan called this process *amplification and amputation*. He used the microphone as an example. The microphone can literally amplify one's voice, but in doing so it reduces the speaker's need to exercise his own lung power. Thus one's inner capacities may atrophy.

"An excess of information may actually crowd out ideas, leaving the mind (young minds especially) distracted by sterile, disconnected facts, lost among the shapeless heaps of data."

This phenomenon is of particular concern with children, who are in the process of developing all kinds of inner capacities. Examples abound of technology's circumventing the developmental process: the student who uses a spell checker instead of learning to spell, the student who uses a calculator instead of learning to add—young people sacrificing internal growth for external power.

Often, however, this process is not so easily identified. An example is the widespread use of computers in preschools and elementary schools to improve sagging literacy skills. What could be wrong with that? Quite a bit, if we consider the prerequisites to reading and writing. We

know that face-to-face conversation is a crucial element in the development of both oral and written communication skills. On the one hand, conversation forces children to generate their own images, which provide connections to the language they hear and eventually will read. This is one reason why reading to children and telling them stories is so important. Television and computers, on the other hand, generally require nothing more than the passive acceptance of prefabricated images.

Now consider that a study reported in *U.S. News & World Report* estimated that the current generation of children, with its legions of struggling readers, would experience one-third fewer face-to-face conversations during their school years than would the generation of 30 years ago. It may well be that educators are trying to solve the problem of illiteracy by turning to the very technology that has diminished the experiences children need to become literate.

Obsolete Lessons

But students need to start using computers early in order to prepare for the high-tech future, don't they? Consider that the vast majority of students graduating from college this past spring

started kindergarten in 1986, two years after Macintosh was invented. If they used computers at all in elementary school, they were probably command-line machines with no mouse, no hard drive, and only rudimentary graphics. By the time these students graduated from college, whatever computer skills they picked up in primary school had long been rendered obsolete by the frenetic pace of technological innovation.

The general computer skills a youth needs to enter the workplace or college can easily be learned in one year of instruction during high school. During the nine years that I taught Advanced Computer Technology for the Des Moines public schools, I discovered that

the level of computer skills students brought to the class had little bearing on their success. Teaching them the computer skills was the easy part. What I was not able to provide were the rich and varied firsthand experiences students needed in order to connect the abstract symbols they had to manipulate on the screen to the world around them. Students with scant computer experience but rich ideas and life experiences were, by the end of the year, generating sophisticated relational databases, designing marketable websites, and creating music videos. Ironically, it was the students who had curtailed their time climbing the trees, rolling the dough, and conversing with friends and adults in order to become computer "wizards" who typically had the most trouble finding creative things to do with the computer.

Certainly, many of these highly skilled young people (almost exclusively young men) find opportunities to work on computer and software design at prestigious universities and corporations. But such jobs represent a minuscule percentage of the occupations in this nation. And in any case, the task of early education is not merely to prepare students for making a living; it is to help them learn how to make a life. For

We know that face-to-face conversation is a crucial element in the development of both oral and written communication skills.

that purpose, the computer wizards in my class seemed particularly ill prepared.

So why is it that schools persist in believing they must expose children to computers early? I think it is for the same reason that we take our children to church, to Fourth of July parades, and indeed to rituals of all types: to initiate them into a culture, in this case, the culture of high technology. The purpose is to infuse them with a set of values that supports the high-tech culture that has spread so rapidly across our society. And this, as we shall see, is perhaps the most disturbing trend of all.

The Ecological Impact of Technology

As the promise of a computer revolution in education fades, I often hear promoters fall back on what I'll term the neutrality argument: "Computers are just tools; it's what you do with them that matters." In some sense this is no more than a tautology: Of course it matters how we use computers in schools. What matters more, however, is that we use them at all. Every tool demands that we somehow change our environment or values in order to accommodate its use. For instance, the building of highways to accommodate the automobile hastened the flight to the suburbs and the decline of inner cities. And over the past 50 years we have radically altered our social landscape to accommodate the television set. In his seminal book *Autonomous Technology*, Langdon Winner dubbed this characteristic "reverse adaptation."

Consider the school personnel who already understand, intuitively, how this principle works: the music teacher whose program has been cut in order to fund computer labs; the principal who has had to beef up security in order to protect high-priced technology; the superintendent who has had to craft an "acceptable use" agreement that governs children's use of the Internet (and for the first time in our history renounces the

school's responsibility for the material children are exposed to while in school). What the computers-are-just-tools argument ignores is the ecological nature of powerful technologies; that is, their introduction into an environment reconstitutes all of the relationships in that environment, some for better and some for worse. Clinging to the belief that computers have no effect on us allows us to turn a blind eye to the sacrifices that schools have made to accommodate them.

Not only do computers send structural ripples throughout a school system, but they also subtly alter the way we think about education. The old saw, "To a man with a hammer everything looks like a nail," has many corollaries. (The walls of my home once

testified to one of my favorites: To a four-year-old with a crayon, everything looks like drawing paper.) One that fits here is, "To an educator with a computer, everything looks like information." And the more prominent we make computers in schools (and in our own lives), the more we see the rapid accumulation, manipulation, and sharing of information as central to the learning process, edging out the contemplation and expression of ideas and the gradual development of meaningful connections to the world.

In reconstituting learning as the acquisition of information, the computer also shifts our values. The computer embodies a particular value system, a technological thought world first articulated by Francis Bacon and René Descartes 400 years ago, that turns our attention outward toward asserting control over our environment. (That is essentially what technologies do—extend our power to control from a distance.) As it has gradually come to dominate Western thinking, this ideology has entered our educational institutions. Its growing dominance is witnessed in the language that abounds in education: talk of empowerment, student control of learning, standards, assessment tools, and productivity.

The task of early education is not merely to prepare students for making a living; it is to help them learn how to make a life.

Almost gone from the conversation are those inner concerns—wisdom, truth, character, imagination, creativity, and meaning—that once formed the core values of education. *Outcomes* have replaced *insights* as the yardstick of learning, while standardized tests are replacing human judgment as the means of assessment. No tool supports this technological shift more than computers.

In the Wrong Hands

There are some grave consequences in pushing technological values too far and too soon. Soon after my high school computer lab was hooked up to the Internet, I realized that my students suddenly had more power to do more damage to more people than any teenagers in history. Had they been carefully prepared to assume responsibility for that power through the arduous process of developing self-discipline, ethical and moral strength, compassion, and connection with the community around them? Hardly. They and their teachers had been too busy putting that power to use.

We must help our young people to develop the considerable moral and ethical strength needed to resist abusing the enormous power these machines give them. Those qualities take a great deal of time and effort to develop in a child, but they ought to be as much a prerequisite to using powerful computer tools as is learning how to type. Trying to teach a student to use the power of computer technology appropriately without those moral and ethical traits is like trying to grow a tree without roots. Rather than nurture those roots, we hand our youngest children machines and then gush about the power and control they display over that rarefied environment. From the earliest years, we teach our children that if they have a problem, we have an external tool that will fix it. (Computers are not the only tools. Ritalin, for example, is a powerful technology that has been scandalously overprescribed to “fix” behavior problems.) After years of this training, when our teenagers

find themselves confused, angry, depressed, or overwhelmed, we wonder why so many of them don’t reach out to the community for help or dig deep within themselves to find the internal strength to persevere, but rather reach for the most powerful (and often deadly) tool they can find to “fix” their problems. Our attempts to use powerful machines to accelerate or remediate learning are part of a pattern that sacrifices the growth of our children’s inner resources and deep connectedness to community for the ability to extend their power outward into the world. The world pays a high price for the trade-off.

The response that I often hear to this criticism—that we just need to balance computer use in school with more “hands-on” activities (and maybe a little character education)—sounds reasonable. Certainly, schools should help young people develop balanced lives. But the call for balance within schools ignores the massive commitment of resources required to make computers work at all and the resultant need to keep them constantly in use to justify that expense. Furthermore, that view of balance completely discounts the enormous imbalance of children’s lives outside of school. Children typically spend nearly half their waking life outside of school sitting in front of screens. Their world is saturated with the artificial, the abstract, the mechanical. Whereas the intellectual focus of schools in the rural society of the 19th century compensated for a childhood steeped in nature and concrete activity, balance today requires a reversal of roles, with schools compensating for the overly abstract, symbolic, and artificial environment that children experience outside of school.

Technology with a Human Purpose

None of this is to say that we should banish computers from all levels of K–12 education. As young people move into subject areas like advanced mathematics and chemistry that rely on highly abstract concepts, computers have much to offer. Young people will also need computer

skills when they graduate. But computer-based learning needs to grow out of years of concrete experience and a fundamental appreciation for the world apart from the machine, a world in which nature and human beings are able to speak for and through themselves to the child. Experiences with the computer need to grow out of early reliance on simple tools that depend on and develop the skills of the child rather than complex tools, which have so many skills already built in. By concentrating high technology in the upper grades, we honor the natural developmental stages of childhood. And there is a bonus: the release of massive amounts of resources currently tied up in expensive machinery that can be redirected toward helping young children develop the inner resources needed to put that machinery to good use when they become adults.

There remains a problem, however. When Bacon began pushing the technological ideology, Western civilization was full of meaning and wretchedly short on the material means of survival. Today we face the reverse situation: a society saturated in material comforts but almost devoid of meaning. Schools that see their job as preparing young people to meet the demands of a technology-driven world merely embrace and advance the idea that human needs are no longer our highest priority, that we must adapt to meet the demands of our machines. We may deliver our children into the world with tremendous technical power, but it is rarely with a well-developed sense of human purpose to guide its use.

If we are to alter that relationship, we will have to think of technological literacy in a new way. Perhaps we could call it technology awareness. Whatever its name, that kind of study, rather than technology training, is what needs to be integrated into the school curriculum. I am currently working with the Alliance for Childhood on a set of developmental guidelines

to help educators create technology-awareness programs that help young people think about, not just with, technology. This is not the place to go into the details of those guidelines. What I want to emphasize here is that they share one fundamental feature: They situate technology within a set of human values rather than out in front of those values. They do not start by asking what children need to do to adapt to a machine world, but rather, which technologies can best serve human purposes at every educational level, and how we can prepare children to make wise decisions about their use in the future.

The most daunting problems facing our society—drugs, violence, racism, poverty, the dissolution of family and community, and certainly war—are all matters of human purpose and meaning. Filling schools with computers will not help find the answers to why the freest nation in the world has the highest percentage of citizens behind bars or why the wealthiest nation in history condemns a sixth of its children to poverty.

So it seems that we are faced with a remarkable irony: that in an age of increasing artificiality, children first need to sink their hands deeply into what is real; that in an age of light-speed communication, it is crucial that children take the time to develop their own inner voice; that in an age of incredibly powerful machines, we must first teach our children how to use the incredible powers that lie deep within themselves.

Lowell Monke taught courses on the philosophy of education and the impact of media on young people at Wittenberg University, OH, until retiring in 2014. Along with authoring numerous articles on technology and education, he was a founding board member of the Alliance for Childhood. He also served as a technology advisor to the Washington Waldorf School for eight years. He now resides in Parker, CO.

Every tool demands that we somehow change our environment or values in order to accommodate its use.

Of Ants and Human Beings

Technology and the Urgent Need for New Ideas to Protect Children,
Our Communities, and the Future

Patrice Maynard

While sitting on the grass attaching stickers to tag sale items not long ago, I was repeatedly interrupted by a group of ants. When my annoyance got the better of me, I paused in the work to examine why there were so many of them. It soon became clear that my choice of workstation was exactly in the path of a very long, single-file line of ants, each carrying a tiny white package. It appeared that the ants were moving house in a systematic way. I traced the line a very long distance before I found the original ant mound from which the parade was emanating.

Picking up one of the ants, I marveled at how energetically the little thing fought me, thrashing around frantically and pounding its miniscule legs against my fingers, while hanging on tenaciously to its small, white package. Looking more closely at the precious cargo, I realized with a kind of shock that the ants were transporting eggs. The fact caught in my throat. The ant put me to shame in its willingness to protect its young. What can we learn from the ants about how to protect little ones this ferociously?

In an interview with me two years ago, Dr. Audra Steiner, of the University Eye Center at SUNY Optometry in New York City, explained that the clinic faced substantial change because their therapy for children was geared toward the cultivation of the small motor skills necessary to improve eyesight for visually impaired children: eye-hand coordination, eye tracking, development of peripheral eye muscles that may have atrophied from over-use of frontal focus, etc. However, the increasing absence of gross motor skills in their clients made the small motor skill therapy more complex. Establishing the first set of skills is best before the second set is developed. The clinic was considering an overhaul, both in the physical plant and in the

training of the clinicians, in which physicians would start with the missing gross motor skill development before tackling the small motor skills they were trained to practice with children. The staff at the clinic observed that the reason for the children's diminishing gross motor skills was the increasing use of screens.

We were speaking together because of one little girl who attended the clinic and who also attended a Waldorf school. This little girl, who had experienced neurological deficiencies in her eyesight from birth, showed remarkable improvement well beyond what those at the clinic thought possible. All on the medical staff were impressed with the effects the Waldorf curriculum had on the child, with the capacities it made possible for this first grader. Dr. Steiner was interested in what was happening in the Waldorf school, curious about what collaboration might be possible.

"Computer Vision Syndrome and Digital Eye Strain" is one health hazard of computer use in the very young¹ (and in adults as well), but neck and back problems, it turns out, are a risk also.² In addition it has been established that too much exposure to HEV (high energy visible light) in youth can increase the risk of macular degeneration later in life.³

Vision is but one area in which health is affected by screens. Electromagnetic exposure from computers, cell phones, electronic pads, and all electronic equipment has now been officially designated a carcinogen.⁴ These devices have been demonstrated to increase the occurrence of hyperactive behavior, sleep disorders, headaches, and depression in children. Moreover, there are now centers to help people with addiction that can occur from screen use and video games;⁵ in some countries (not yet in the U.S.) computer

addiction, especially to video games, has been declared an official clinical disorder.⁶

A 2015 article in *The New York Times* described the toll these games are taking on children. In 2013 “Internet Gaming Disorder” was placed in the chief psychiatric guidebook, the *Diagnostic and Statistical Manual of Mental Disorders*.⁷

In *The New York Times* article, “A Silicon Valley School That Doesn’t Compute,” a front page story, Sunday, October 23, 2011, by Matt Richtel,⁸ we read that the engineers and designers of electronic “toys” in Silicon Valley, understanding that these devices are not wholesome for children, do not allow their children to play with these things. Many of them have their children in “low-tech” Waldorf schools, where technology is held back until high school, and even then its use is limited. In a different *New York Times* article in 2015, we learned that Steve Jobs was a “low-tech parent” who did not allow his children to use the devices Apple made.⁹

The same Matt Richtel of the 2011 report wrote in a more recent article that the only research claiming to show that computers improve children’s performance in school were those conducted by Microsoft and Apple.¹⁰

Based on both the overwhelming body of research and information available on all these dangerous aspects of electronic usage, especially for youngsters in our culture, and to the presence of “helicopter parents,” it is difficult to understand the rampant use of electronics among children. Twice as many children have cell phones now as in 2004. Most teens, 85% of those aged 14 to 17, have cell phones. So do 69% of 11–14-year-olds and 31% of kids aged 8–10, according to a 2010 survey by the Kaiser Family Foundation.¹¹

Electromagnetic exposure from ... all electronic equipment has now been officially designated a carcinogen.

...[E]lectronics might become the asbestos “class action suit” of the 21st century.

Michaela Glöckler, MD, former Head of the Medical Section at the Goetheanum in Dornach, was reported to have speculated at a 2014 conference that electronics might become the asbestos “class action suit” of the 21st century.

While the value of electronics and rapid communication is undeniable, their proper use for maximum health and value lags very far behind the rate of their invention. The speed with which electronics have become “ordinary” in our culture is astonishing. The way computers and electronics have solved problems, especially in the fields of information sharing

and medical practice, is impressive. This makes it easy to hear in the marketing of these devices the promises made about the potential of electronics and the optimistic hope we hold for them to solve all our problems sometime soon.

However, there are a couple of particularly tragic results of this rapid “normalization” of electronics. Children’s disconnection from the natural world is one of them; the social problems these devices create, most notably in the arena of communication and care for others, is another.

Though it isn’t responsible to liken “Nature Deficit Disorder”—a non-medical term coined by Richard Louv in his book, *Last Child in the Woods*—or social misunderstandings to the health hazards listed above, the destructive power of electronics is illustrated by stories we

hear in our culture and even in our Waldorf communities.

On a recent canoe trip, a trip leader lamented that the number of families who explore the beauty of the natural surroundings of river wildlife has diminished in recent years. He reported, “Parents say that such a canoe trip just doesn’t have enough excitement for their children.” While it is true that the entire activity of, say, a duck on a pond on any given

day might take the form of paddling once or twice from one end of the pond to the other, fishing now and then along the way, there was a time when children could sit by the edge of the pond and enjoy the very slowness of the action. Now children's expectations are often built by "nature shows" that explain how an animal likes to sleep most of the time in the shade, but the footage that goes along with the narration shows copulation, birth, wrestling with the young and disciplinary action, mother animal to baby, in a three-minute span of time. No wonder youngsters poke sticks at sleeping animals and wonder where the action is.

Waldorf schools plead with parents to keep little ones away from all screen technology—TVs, computers, electronic pads, cell phones, etc.—until at least the upper end of elementary school. Further, Waldorf schools ask parents to avoid using all media around the young. The

goals are multifarious, but the work to unite children through their school experience with the real world before the virtual world, especially with the realms of nature in deep, living, and caring ways is one paramount goal.

This goal can lead to a number of social problems. Waldorf schools are sometimes ridiculed, as are Waldorf teachers, for taking a stand against the early use of media. A "get with it" message comes from one segment of the parent body. On the other hand, many other parents are relieved to find a school that asks for this kind of adherence for the sake of protecting childhood. In this group, frustration may result if a teacher or a school is perceived as being too lax about enforcing its media policies. Factions can develop then in the community—"good" parents and "bad" parents. Sometimes parents will lie, saying they do not have devices in their homes when, in fact, they do. Students may describe a movie they saw and then catch themselves in

front of a teacher, saying, "Oh, my father told me not to tell you that I saw it."

Sleepovers with friends, birthday parties, and recreational activities can all become contentious within a class of children when movies are shown or video games are used as entertainment in some homes, while in others this is never part of the activity agenda. Children in the elementary grades who watch movies come to school acting out what they have seen, telling in detail the storyline of a movie, singing the songs of the movie soundtrack (*Frozen* was a recent, popular example). This influences the free play of youngsters and can elicit arguments at home

("Everybody in school has seen this except me!"), or isolate children who do not know the songs because they did not see the movies. It can also interfere with lessons. When a teacher tells, for example, of ancient Egypt in grade five, and a child has seen a movie about Egypt, arguments can

erupt about which is correct: movie or teacher. Any mood of awe or wonder the teacher might have been yearning to generate is lost. Fairy tales in their original form become "wrong" because fairy tales in movies are so very different from their original versions. Vivid pictures of movies are taken in by first through fourth graders as "truth." Imagination wanes as media pictures supplant the inner pictures that children need to create in order fully to experience an orally-told story. Moviegoers sometimes ridicule children who do not go to movies. Some children can have nightmares from movies or even from vividly described movies.

Woven into this social undermining are perhaps the dangerous judgments that can go from family to family. In more than one school community, whole classes have been ripped apart by conflicts connected to these issues, these judgments. An illuminating situation erupted when in one school community a third grader

The Waldorf curriculum [is] designed to bring the very antidote needed for all the distraction, demoralizing, and negative social trends possible with electronics.

had a friend over to play. The two little boys got into an unguarded and unprotected computer at the home of the play date. Very quickly, within twenty minutes or so, the boys ended up on a pornographic site.

The host family in whose home this occurred was understandably mortified, apologetic, and upset that this had happened. The community turned its back on the family and ostracized them, asking the school to expel the child and thereby “get rid of” the family. The family of the child who went to that home felt that their son had been irrevocably damaged. Some people even asked the host parents, “Why send your child to a Waldorf school if you do not believe in its ideals and follow its recommendations?” Hostility then poured out against all families who had casual practices around electronic devices. Under this pressure, increased lying about actual practices set in. Because the class teacher expressed compassion for the situation and for the family whose home was the scene of the incident, many families were angry with the teacher. Some even withdrew their children to get them to a more “pure” and safe environment. The school lost credibility, enrollment, and stability.

There are even darker stories of youngsters lost or abused through unsupervised Internet activities. Pre-teens, who in their very nature tend toward experimentation and secretive plans, are vulnerable to predators who have unlimited access and can disguise their age, intentions, and identity using social media.¹²

Cyber bullying and anonymous “hazing” can drive young people to extremes such as suicide and dangerous revenge games.¹³ “Trash talk” in social media, “sexting,”¹⁴ and other degrading activities encourage habits of thought and expression that go in the opposite direction of

“lofty,” or “poetic,” or “philosophical.”¹⁵ Texting, Facebook, instant messaging, and What’s app can usurp a teen’s time and develop other sorts of habits of behavior and thinking.¹⁶

Of course, the opportunity is contained in all of these “new” possibilities to build more conscious communities with clear agreements about a desirable way of life for us and for our children. Research evidence supports Dr. Glöckler’s prediction that electronic devices will, in the near future, become the asbestos and tobacco of the second half of the 21st century. The deliberately misleading marketing during the 20th century of both tobacco and asbestos—as

well as the suppression of known information concerning the lethal effects of these substances in order to increase sales and profits at the expense of human health—is instructive for us. The drive to protect profits is perhaps even stronger now than it was in the past. However, pro-activity on the part of a conscious parental and educational community could make an environment for children

much less stressful, more wholesome, more playful, more linked with the natural world, and more in keeping with the ordinary tendencies of childhood. The Waldorf curriculum, daily artistic activity, involvement in making music are all designed to bring the very antidote needed for the distraction, demoralizing, and negative social trends possible with electronics.

Rather than wishing for Waldorf communities to catch up with the modern world and to “get with it,” we could imagine Waldorf communities as being ahead of the times, protecting generations of children while the world “catches up” to available research. They could employ the available research data and behave more like the ant kingdom in the energetic protection of children than like “sheeple,” following advertising

Rather than wishing for Waldorf communities to catch up with the modern world and to “get with it,” we could imagine Waldorf communities as being ahead of the times, protecting generations of children while the world “catches up” to available research.

shepherds in the pursuit of the latest media frenzy. Strength in the individual, or ethical individualism, in an awake community is possible. Using technology as tools in support of our own creativity as human beings is the highest and best application of technology.

In the process, a deliberate and crystal-clear goal could be to develop cooperating communities that work consciously together to build agreements based on the wisdom of everyone included in the community. Imagine agreements that are kept and admired and that leave all free from ridicule. The effect on the students in that community could be powerful and long lasting. A few initial ways to begin this process might include:

- Articulated goals to protect children from all harmful substances until well into late teenage years (e.g., 17 or 18);
- Collected research that underscores the value of the first practice, made readily available for all in a school community to study;
- Articulated agreements, class to class, on practices during play dates, sleepovers, birthday parties, and other social gatherings involving youngsters so that all parents can rely on each other to uphold the agreements made;
- Clearly defined agreements on the use of texting, email, and social media in a school community;
- Practices in place on how to uphold agreements in quick, clear ways that avoid judgment and affirm the original agreements;
- Informational sessions for community members about child development, the critical times of change in a youngster's growth, and how the Waldorf curriculum

is designed to support these nodal points for strength in the adult that the child will become;

- Published lists of community-designed activities that offer alternatives to technology-oriented activities;
- Helpful support for families who might have difficulty keeping agreements;
- Trust, courtesy, laughter, and friendliness developed as conscious activities in a community.

Of course, our Waldorf curriculum already holds within it much of these community-building

practices. At the same time, Waldorf schools have celebrated the excellence of electronics as the tools they are, working in a systematic way to include computer technology in math and science classes once the students are old enough to have developed skills of clear thinking and analysis on their own. In this way students can, in turn, understand electronic devices both as the marvelous tools they are and as the support they can provide as aids in strategic thinking and quick research. The resilience of soul and maturity of feelings that the rich and multifarious use of the arts in

the curriculum cultivate can prove to be a shield against over-dependence on all but human skills. Problem-solving, depth of understanding of technology, and creativity, particularly for those who continue through to graduation from grade twelve in a Waldorf school, are skills that are cited repeatedly by professors and employers who enjoy teaching and hiring Waldorf graduates. 42% of Waldorf high school graduates enter fields of the sciences, including technology. Some have won awards for using their artistic sensibilities to design models and graphics that are unusually

[P]ro-activity on the parts of a conscious parental and educational community could make an environment for children much less stressful, more wholesome, more playful, more linked with the natural world, and more in keeping with the ordinary tendencies of childhood.

illuminating in presenting complex concepts and new techniques.

Using research as tools for honest and constructive community-building and sustaining might be the best use of all the research we now have available about the great potential and degrading dependence possible in using technology. Protecting children in light of the results of studies available is more urgent, perhaps, than the marketing of electronics and technology might lead the world to believe. Taking time to understand the research and to develop good practices might be time well spent—inefficient in the short run and most efficient in the long run. The patience and determination of the ant kingdom is the picture to hold.

ENDNOTES

1. <http://www.allaboutvision.com/cvs>.
2. <http://www.healthline.com/health-news/screen-time-hurts-more-than-kids-eyes-101215>.
3. <http://www.allaboutvision.com/cvs/blue-light.htm>
4. <http://emwatch.com/computer-radiation-may-damage-your-health>.
5. http://well.blogs.nytimes.com/2015/07/06/screen-addiction-is-taking-a-toll-on-children/?_r=0.
6. <https://cellphonesafety.wordpress.com/category/hyperactivity>.
7. http://www.huffingtonpost.com/richard-freed/the-science-and-tragedy-behind-the-new-york-times-screen-addiction-is-taking-a-toll-on-children_b_7765790.html.
8. <http://www.nytimes.com/2011/10/23/technology/at-waldorf-school-in-silicon-valley-technology-can-wait.html>.
9. <http://www.nytimes.com/2014/09/11/fashion/steve-jobs-apple-was-a-low-tech-parent.html>.
10. <http://www.nytimes.com/2011/09/04/technology/technology-in-schools-faces-questions-on-value.html>.
11. <http://kff.org/disparities-policy/press-release/daily-media-use-among-children-and-teens-up-dramatically-from-five-years-ago>.
12. http://www.tandfonline.com/doi/abs/10.1300/J070v16n02_02.
13. <http://www.netsmartz.org/Cyberbullying>.
14. <https://www.psychologytoday.com/blog/teen-angst/201207/the-dangers-teen-sexting>.
15. http://www.collegiatetimes.com/opinion/social-media-can-hurt-self-esteem/article_f1a76d80-3931-11e4-af3e-001a4bcf6878.html.
16. <http://www.cnn.com/2010/TECH/04/20/teens.text.messaging>.

Patrice Maynard, MEd, is the Director of Publications and Development at the Research Institute for Waldorf Education (RIWE). She currently teaches teachers at several Waldorf teacher preparation institutes in North America as an adjunct faculty member. She earned her masters degree at Antioch New England University. She was leader for Outreach and Development for the Association of Waldorf Schools (AWSNA) for nine years and taught for thirteen years prior to these positions as a class teacher and as a music teacher at the Hawthorne Valley School in Harlemville, NY, where she lives with her husband. A founding member of the board of the Merriconeag Waldorf School in Freeport, ME, she is the proud parent of three Waldorf graduates. Patrice is a published poet, gardener, and quilter.

Seeing in Physics and Chemistry

Grades School Science Training for Waldorf School Teachers

Amalia Pretel-Gray

In true perception – nothing
No thing is present
Present to the possibility of sensation
Sensation that requires inner awareness
Awareness that yields subtle understanding
Understanding that knows relationship
Relationship is the world.
A world that requires inner participation.

– Michael D'Aleo

What Is Being Asked of You

Science teaching needs ... a combination of kindling the sparks of imagination, quieting the soul ... and presenting intellectual material so that intuitive truths can be experienced. When we do this we attend to both content and character. We help students move from apathy to wonder, from wonder to knowing, and from knowing to gratitude.

– David Mitchell, *The Wonders of Waldorf Chemistry*

*T*welve years ago, I attended a weekend workshop on the essence of teaching physics and chemistry to Waldorf upper elementary school students, led by Michael D'Aleo at the Lexington Waldorf School. He signed his book, *Sensible Physics Teaching*, which I had purchased that weekend, and asked if I would be interested in taking a course he was developing, along with Gary Banks, Lylli Anthon, and Barbara Richardson. Two years later, the first Teaching Sensible Science (TSS) course for Waldorf teachers began in 2006, sponsored by the Saratoga Natural Science Research Institute (SENSRI) and the Research Institute for Waldorf Education (RIWE). At that time I was teaching fourth grade at the Meadowbrook Waldorf School and could think

only of how necessary this course would be to me, an English Literature major, in order to teach the sciences in a true, meaningful, and appropriate way during the sixth, seventh, and eighth grades. I was inspired to take this new course, as was my colleague, Judie Sky, who joined me for the inaugural session. We were so moved by our first class that we began a “teachers-teaching-teachers” session once a month on Tuesdays to share what we had learned. We brought the methods and techniques of this phenomenological science to our students with as much enthusiasm as they had been brought to us by Michael, Lylli, and Gary.

This past year, Michael D'Aleo came to speak to the faculty and parents of the Waldorf School of Garden City, where now I am a class teacher. Ten years have passed since my taking the TSS course. Michael spoke to the faculty at an entirely new level regarding phenomenological science. Again, I was inspired. What was I hearing now? I spoke to Michael after the lecture and asked him how the science course had developed since the time I had taken it. Needless to say, after listening to Michael's lecture to faculty, and then later to parents, it was evident to me that it was time for me to refresh and develop further what I had learned through my first experience of the TSS course.

So, there I found myself in the 2016 TSS course, hosted this time by the River Valley Waldorf School in eastern Pennsylvania. One of the main developments I found in this year's course was the enhanced use of Socratic dialogue. The daily activity of living into the phenomena before us, of using our thinking and feeling actively, enlivened these forces within us. This was evident in our dedication to pulling out of ourselves both what each of us was seeing and

what language we could agree on to describe what we were seeing. Out of this consistent work, with Michael continually asking us questions about what we were seeing and describing, our own thinking opened to the natural world and its life forces. It was as if we became the phenomena themselves, actively empathic to their existence, and as a result, coming to understand them deeply. We were fully living with the questions “What is the truth of what I see before me?” and “How true is my language, am I, to what is before me?” This experience was completely transforming.

The course was divided into three sessions, each focused separately on grade, 6th, 7th, and 8th grade physics and chemistry, with some months in between to practice the ideas developed in each session. We presented experiments to each other, then wrote these up with the developmental phases of the students in mind. We struggled to be clear and precise in our descriptions, speaking out of what we were actually seeing rather than from what we thought we might be seeing. Interspersed with this work was the practice of eurythmy with Barbara Richardson, who provided the foundation from which Michael, Lylli, and Gary worked to integrate science and art in a single unified experience.

The hands-on work of this TSS course allowed us to see the nuances of how an experiment can be successfully presented. For instance, the seventh grade physics experiment of taping a long string to the center of a mirror, pulling it taut at different angles, and looking into the line of vision could have easily gone awry without the aid of the course. It helped us develop language that avoided the dead, materialistic concepts presented in textbooks. When later I put the principles taught in the TSS course into action in the classroom, I found the students enthralled by both the experiments and the subsequent conversations. A particularly important experiment—the “camera obscura”—engaged my students deeply in an experience starting with absolute darkness in which nothing could

be seen until a pinhole punctured in the window shade immediately lightened a white sheet placed in front of them. Inevitably resounding in the room was “I love physics!” Because of the length of time between each of the 6th, 7th, and 8th grades sessions, we were able to put what we had learned into practice and then bring our experiences back to the course for sharing and review.

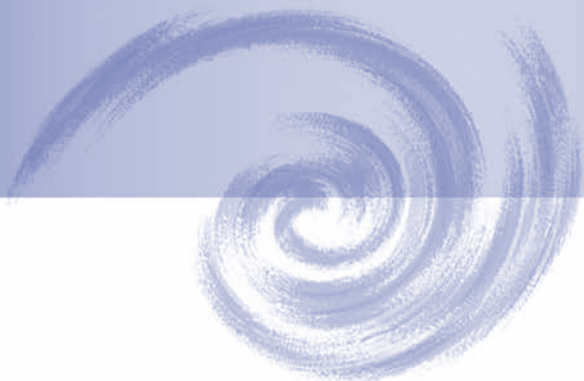
Setting up the conditions for the students to experience the phenomenological truth is fundamental to the teaching of the sciences. Through this Teaching Sensible Science course, we have come to see that this practice of both observation and language usage is critical to the outcome. The combination of how we elicit from the students what they see and how they write about what they see was taken to a new level of understanding based on the activity of both the course presenters and the participants in the course. Practicing precise language in our course dialogues gave us the tools to learn how to lead the students through the ensuing stages of writing their main lesson books: the steps we took, what we did, what we saw, where we see this in life, what phenomena we could identify that had specific patterns, and what truth could be stated about these patterns. We engaged our life forces heartily and our enthusiasm endearingly to come to consensus about the Truth before us, putting ourselves entirely in the shoes of the students as they would come newly to this practice.

Articulating these stages stirred my own capacity to engage in a true science, one that is actively asking for my presence, for my releasing of abstractions and old thoughts, for my confidence and inspiration, and for my looking with new eyes, new speech, and new ears. If I am interacting in this way and practicing this seeing and listening, then I am a living and active teacher, which is what is asked of us as Waldorf teachers. Being in this TSS course ten years ago had already opened me to science in a new way, but now, ten years later, it opened new capacities

in me that are transforming my thinking and how I relate to the world.

The TSS course not only provided the foundation and capacities for teaching physics and chemistry, but also enhanced other areas of a Waldorf teacher. That same conscious seeing and use of language in our science experiments can be applied in the social realm as well. Child Study, faculty discussions, and decision-making are but a few of the areas where this phenomenologically active and engaging thinking can create clarity and where together, through the commitment to come toward the truth, the human being, the child before us, and the content needed to make a decision can each be enlivened. Courage is basic, imagination is fundamental, and enthusiasm underlies it all.

Amalia Pretel-Gray *is a Waldorf class teacher who has been teaching for 21 years in several Waldorf schools.*



Report from the Online Waldorf Library

Marianne Alsop

The Online Waldorf Library (OWL) continued to attract both American and international interest during the first seven months of 2016, receiving over 85,000 site visits primarily from the USA, UK, Australia, Canada, India, Spain, Philippines, Russia, New Zealand, and South Africa. An upgrade of OWL's search engine has streamlined our article and book-search features to help site visitors find what they are looking for with greater speed and efficiency.

Our focus on providing articles and eBooks translated into Spanish continues with a host of new articles added during the past few months. New eBooks in Spanish include *En la Fuente* by Harlan Gilbert; *Salud a Través de la Educación* from the 2006 Kolisko Conference; *Completando el Círculo* by Thomas Poplawski; *Las Aventuras de la Crianza* by Rachel C. Ross; and *Aritmetica Activa!* by Henning Andersen. From our colleagues at Editorial Rudolf Steiner S.L. in Madrid, we now have posted these titles: *Los Doce Sentidos del Hombre*, *El Estudio del Hombre Como Base de la Pedagogia*, and *Coloquios Pedagógicos y Conferencias Curriculares Vol. III*, all by Rudolf Steiner, as well as *Educación Waldorf*, by Christopher Clouder and Martyn Rawson. We are grateful to Editorial Rudolf Steiner S.L. for these and a number of other titles that will be posted this year.

Our first book in Mandarin, *Handwork: Indications* by Rudolf Steiner, also came online.

Recently added eBooks in English from the Waldorf Early Childhood Association include: *From Kindergarten into the Grades* and *You're Not the Boss of Me!* by Ruth Ker; *Supporting Self-Directed Play in Steiner/Waldorf Early Childhood Education* by Renate Breipohl; *Simply Sourdough* by Lory Widmer-Hess; *Seeking the Spirit*, compiled by Helmut von Kùgelen; and *Working*

with the Angels: The Young Child and the Spiritual World, Gateways Series Two.

Further selections of eBooks in English published by Waldorf Publications were also added during the course of the year: *Rubicon, Developmental Steps Ages 7 to 10, Selections from the Works of Rudolf Steiner*; *Liputto* by Jakob Streit; *Recorder Ensemble* by Steve Bernstein; *The Invisible Boat* by Eric Müller; *Creating a Circle of Collaborative Spiritual Leadership*, Pedagogical Section Council of North America; *The Grail Mystery and the Seven Liberal Arts* by Frans Lutters; and revised and reformatted editions of *One Way to Teach the Writing of Poetry* by Christy Barnes, *Observations on Adolescence, the Third Phase of Human Development* by Rudolf Steiner, *Research* by Torin Finser, *Roman Lives* by Dorothy Harrer, and *Let's Talk, Let's Play* by Jane Eliot.

For the first time, four audio books were added to the Online Waldorf Library. These can be found via the Home page directory list on the far left of the page. These include: *Assessment for Learning in Waldorf Classrooms* (ten chapters) and *A Phenomena-Based Physics*, Volume 1 for Grade 6, Volume 2 for Grade 7, and Volume 3 for Grade 8, all by Manfred von Mackensen.

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

Visit the
Online Waldorf Library
at
www.waldorflibrary.org

Report from Waldorf Publications

Patrice Maynard

Two research projects that promise excellent publications, once complete, include a new Survey of Waldorf Graduates, a project first undertaken in 2005, and a collection of stories by teachers, parents, and students of moments when the heart-to-heart connection between a teacher and a youngster makes transformation possible.

The Avalon Initiative is a thought leadership group dedicated to developing and disseminating educational ideas designed to balance current trends with correct pictures to support both child development and useful schooling. www.heartsspeak.net is the platform to which to go to tell a story of transformation made possible through relationship, care, and interest. The research derived from the collection of stories promises to illuminate the magic made possible between human hearts—and impossible with artificial intelligence.

The new Survey of Waldorf Graduates will be led by Liz Beaven, who plans to expand the scope of questions as well as the pool of survey participants. Since the last survey was conducted over a decade ago, the number and variety of Waldorf high schools has increased by more than 50%. A publishable compendium of results from the forthcoming survey is scheduled to be available in time for the centennial celebration of Waldorf education in 2019.

Last year, in addition to publishing ten new titles, Waldorf Publications launched its first audio books on the Online Waldorf Library (OWL) of the Research Institute. At the same time, the first Mandarin manuscripts joined an ever-growing collection on OWL of Spanish articles and eBooks. Also underway is a book of Lakota stories and verses from the work of the classroom in South Dakota.

At long last, subscribers to the *Research Bulletin* will now have the option to read issues online. Subscribers will be able to choose online only (strongly recommended for foreign subscribers, given the exorbitant cost of postage to countries beyond the US), mailed print copies, or both. Simulated page-turning gives a “virtual reality” feeling to online research reading. One subscription buys the choice.

Among the ten new titles released in print during the past school year is *Raphael and the Mystery of Illness and Healing*, based on notes of Michaela Glöckler’s lectures and comments offered over three summers during her “Renewal Course” at the Center for Anthroposophy in Wilton, NH. This little booklet emanates from Dr. Glöckler’s decades of work as a physician in Waldorf schools as well as her research and practice as Head of the Medical Section at the Goetheanum in Dornach. Proceeds from the book will support the work of the Medical Section.

As we enter the new school year, many new resources for teachers and parents are forthcoming. One that promises to be helpful for all, particularly new teachers, is a collection of articles assembled by Elizabeth Auer, *Helping Children on Their Way*. An impressive line-up of experienced Waldorf teachers addresses the many possibilities available for giving children support through their school years: form drawing, extra lesson work, child study, meditative practice, sleep, parent relations, movement, and many more topics. The book, lavishly illustrated by the editor, contains an outpouring of possibilities for keeping children happy and moving forward in the Waldorf classroom.



Indices of Past *Research Bulletins*

Volume I, Number 1

- Waldorf Education in an Inner City Public School System
– Research Report
- Encounters in Waldorf Education: A Tribute to Ernst Boyer
– Eugene Schwartz
- Waldorf Education Research Institute in North America
– Susan Howard and Douglas Sloan

Volume I, Number 2

- Racism and Waldorf Education – Ray McDermott and Ida Oberman
- Reflections on the Education of Consciousness – Douglas Sloan
- Standardized Testing in a Non-Standardized World – Eugene Schwartz
- Africa – Betty Staley
- Research in the Life Sciences – Craig Holdrege

Volume II, Number 1

- TECHNOLOGY ISSUE including:
- Violence and the Electronic Media: Their Impact on Children
– Joan Almon
- Building on Shifting Sands: The Impact of Computer Use on Neural and Cognitive Development – Donna M. Chirico
- Meetings with a Snake – Stephen Talbott

Volume II, Number 2

- A New Educational Paradigm – Michaela Glöckler, MD
- Changes in Brain Formation – Michael Kneissle
- Organology and Physiology of Learning – Wolfgang Schäd
- New Health Problems of Children and Youth
– University of Bielefeld (Germany)
- Rudolf Steiner's Efforts to Encourage Cultural Diversity
– Detlef Hardorp
- The Middle Passage—Out of Diversity We Become Whole
– Cindy Weinberg

Volume III, Number 1

- Schooling and the Post Modern Child – David Elkind
- Developing a Culture of Leadership, Learning, and Service in Waldorf Schools – Christopher Schaefer
- The Third Space – Henry Barnes
- What Conditions Are There for Taking Responsibility in an Independent Culture? – Heinz Zimmerman

Volume III, Number 2

- Educating the Whole Person for the Whole Life – Gerald Karnow, MD
- Understanding the Etheric Organization in the Human Being: New Insights through Anthroposophical Research
– Michaela Glöckler, MD
- Endangered Childhood – Joan Almon

Volume IV, Number 1

- ADHD – the Challenge of Our Time – Eugene Schwartz
- Helping Children: Where Research and Social Action Meet
– Joan Almon
- Computers, Brains, and Children – Stephen Talbott
- Movement and Sensory Disorders in Today's Children
– Peter Stuck, MD
- Can Waldorf Education Be Practiced in Public Schools? – Patti Smith

Volume IV, Number 2

- Human Biography and Its Genetic Instrument
– Michaela Glöckler, MD
- Challenges and Opportunities in Evolution Education
– James Henderson
- The High Stakes of Standardized Testing – Edward Miller
- Ecology: Coming into Being versus Eco-Data – Will Brinton
- Genes and Life: The Need for Quantitative Understanding
– Craig Holdrege

Volume V, Number 1

- The Real Meaning of Hands-On Education – Frank Wilson, MD
- America's Gold Rush: Can It Be Redeemed? – Dorit Winter
- Atopy in Children of Families with an Anthroposophic Lifestyle
– Johan S. Alm, MD, et al.

Volume V, Number 2

- Balance in Teaching, Balance in Working, Balance in Living
– Roberto Trostli
- Adult Education in the Light of Anthroposophy – Michael Howard
- Setting Priorities for Research: Attention-Related Disorders (ARD) Study – Kim Payne and Bonnie River-Bento
- Learning Expectations and Assessment Project (LEAP)
– Leap Project Group (Staley, Trostli, K. & B. Anderson, Eaton)
- Sexual Abuse in Children: Understanding, Prevention, and Treatment
– Michaela Glöckler, MD

Volume VI, Number 1

- Confronting the Culture of Disrespect – Langdon Winner
- Where Is the Waldorf School Movement Going? – Johannes Kiersch
- Computers in Education: Why, When, How
– Lowell Monk and Valdemar Setzer
- Low SES Minority Fourth-Graders' Achievement
– Jennifer Schieffer and R.T. Busse

Volume VI, Number 2

- Trained to Kill – Dave Grossman
- Education of the Will as the Wellspring of Morality
– Michaela Glöckler, MD
- Hand Movements Sculpt Intelligence – Arthur Auer
- The Online Waldorf Library Project – Dave Alsop

Volume VII, Number 1

- Creating a Sense of Wonder in Chemistry – David Mitchell
- Science as Process or Dogma? The Case of the Peppered Moth
– Craig Holdrege
- Spirit Will and Ethical Individuality – Michael Howard
- Did Rudolf Steiner Want a Seven-Grade Elementary School Configuration? – Mark Riccio
- Phases and Transitions in Waldorf Education – Harlan Gilbert
- Waldorf High School Research Project: Who Is the Teenager Today?
– Douglas Gerwin
- Initial Report of the Waldorf ADHD Research Project
– Kim Payne, Bonnie River-Bento, Anne Skillings
- International Survey of the Status of Waldorf Schools
– Earl Ogletree
- Case Study Research: The Waldorf Teacher – Nina Ashur

Volume VII, Number 2

- On Forgetting to Wear Boots – Stephen Talbott
- Organizations as Living Organisms: Developing a Seven-Fold View
– Magda Lissau
- Educating the Will—Part II: Developing Feeling Will in Contrast to Sense/Nerve Will – Michael Howard
- Recapitulation and the Waldorf Curriculum – Alduino Mazzone

Volume VIII, Number 1

- No Such Thing: Recovering the Quality of Rudolf Steiner's Educational Work – Stephen Keith Sagarin
- Beyond Innovation: Education and Ethos in an Era of Ceaseless Change – Langdon Winner
- How Poems Teach Us to Think – Gertrude Reif Hughes
- Educating the Will—Part III: Common Will and Comprehensive Will – Michael Howard
- Whom Are We Teaching? – Susan Kotansky

Volume VIII, Number 2

- The Vital Role of Play in Childhood – Joan Almon
- In What Respect Are Star Children Different? – Georg Kühlewind
- The Hague Circle Report – James Pewtherer and Monique Grund
- Special Section: The Push for Early Childhood Literacy: Taking a Careful Look – Editor's Introduction
- Moving in Slow Motion – Barry Sanders
- A Risk Factor in Child Psychopathology – Sharna Olfman
- Critical Issues and Concerns – Nancy Carlsson-Paige
- The Loss of Nature – William Crain
- The Push for Early Childhood Literacy: A View from Europe
– Christopher Clouder

Volume IX, Number 1

- Rudolf Steiner and the New Educational Paradigm
– Christof Wiechert
- Teaching as Learning in a Steiner/Waldorf Setting
– Christopher Clouder
- Education Towards Health Is Education Towards Freedom
– Johannes Denger
- The Stranger in the Mirror: Reflections on Adolescence in the Light of Movement Education – Jaimen McMillan
- Pulling the Grass Doesn't Make It Grow Any Faster
– Gerald Huether
- The New Generation of Children – Renate Long-Breipohl

Volume IX, Number 2

- Wellsprings of the Art of Education: Three Reversals in the Work of the Waldorf Teacher – Christof Wiechert
- Discovering the True Nature of Educational Assessment
– Paul Zachos
- The Kindergarten Child – Peter Lang
- The Teaching of Science – David Mitchell
- Evolution of Consciousness, Rites of Passage, and the Waldorf Curriculum – Alduino Mazzone

Volume X, Number 1

- Science and the Child – Stephen Talbott
- Can Meditation Take the Place of Exercise?
– Michaela Glöckler, MD
- Non-Verbal Education: A Necessity in the Developmental Stages
– Michaela Glöckler, MD
- Organic Functionalism: An Important Principle of the Visual Arts in Waldorf School Crafts and Architecture – David Adams
- The Lowering of School Age and the Changes in Childhood: An Interim Report

Volume X, Number 2

- The Current Debate about Temperament – Walter Rietmüller
- Waldorf Education: Transformation Toward Wholeness
– Vladislav Rozentuller and Stephen Talbott
- The Art and Science of Classroom Management – Trevor Mephram
- Spiritual Research: Casting Knowledge into Love
– David Mitchell and Douglas Gerwin
- Research on Graduates in North America, Phase I
– Faith Baldwin, Douglas Gerwin, and David Mitchell

Volume XI, Number 1

- Puberty as the Gateway to Freedom – Richard Landl
- Soul Hygiene and Longevity for Teachers – David Mitchell
- The Emergence of the Idea of Evolution in the Time of Goethe
– Frank Teichmann
- The Seer and the Scientist – Stephen Keith Sagarin
- The Four Phases of Research – adapted from Dennis Kloeck
- Reports from the Research Fellows:
 - Beyond Cognition: Children and Television Viewing
– Eugene Schwartz
 - PISA Study – Jon McAlice
 - State Funds for Waldorf Schools in England – Douglas Gerwin
 - On Looping – David Mitchell
 - The Children's Food Bill – Christopher Clouder
 - Waldorf Senior Survey
– Waldorf High School Research Project (Gerwin, et al.)

Volume XI, Number 2

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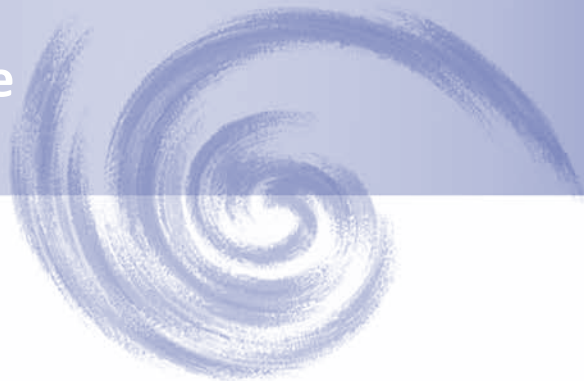
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The Research Institute for Waldorf Education (RIWE), founded in 1996 in order to deepen and enhance the quality of Waldorf education, engages in sustained dialogue with the wider educational-cultural community and supports research to serve a wide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

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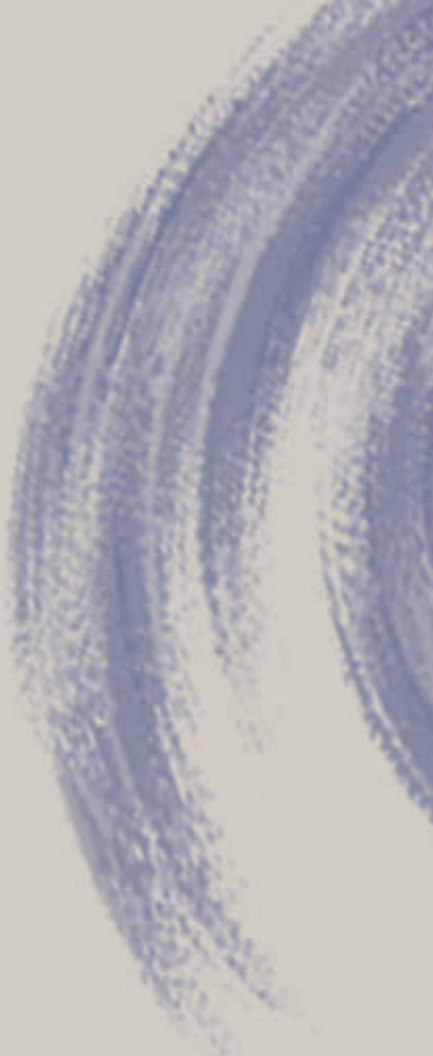
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