

Notes

Preface

1. Marvin elaborates on the importance of computer science:

I think that Computer Science is the most important thing that's happened since the invention of writing. Fifty years ago, in the 1950s, human thinkers learned for the first time how to describe complicated machines. We invented something called computer programming language, and for the first time people had a way to describe complicated processes and systems, systems made of thousands of little parts all connected together: Before 1950 there were no languages that people could use to exchange ideas about such complex things.

Why is that important to understand? Because that's what we are: each human individual is a complex network of machines! So, Computer Science is important, but that importance has little to do with computers themselves; Computer Science is a new philosophy about complicated processes, about life (both artificial and natural) and about intelligence (also both artificial and natural). It can help us understand our brain. It can help us understand how we learn and what knowledge is.

(From a public lecture delivered at the Artificial Life V conference in Nara, Japan, May 16, 1996. [Transcription by Nicholas Gessler.]

2. Marvin Minsky, *The Society of Mind* (New York: Simon & Schuster, 1986); Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006).

3. Seymour Papert, “You Can’t Think about Thinking without Thinking about Thinking about Something,” *Contemporary Issues in Technology and Teacher Education* 5, no. 3/4 (2005): 366–367, <https://eric.ed.gov/?id=EJ1080976>.
4. Minsky, *Society of Mind*.
5. Cynthia Solomon, Margaret Minsky, and Brian Harvey, *LogoWorks: Challenging Programs in Logo* (New York: McGraw-Hill, 1986).
6. Here is a memorable excerpt from Mike Travers’s 2016 blog post entitled “Firing Up the Emotion Machine” (<http://omniorthogonal.blogspot.com/2016/01/firing-up-emotion-machine.html>):

He was I suppose a reductionist, but to label him that is to reduce his own complicated way of thought to a single-word slogan. And that was one kind of reduction he did not practice. His other big trick was to know that there is no one big trick to the mind, that single-idea solutions like logic or bayesianism are insufficient, and that building a mind requires the complex orchestration of multiple mechanisms. *Society of Mind* was itself structured as a cooperating network of very specific ideas for mechanisms, making the form match its content. ... So he tried to take intractable concepts like selves and consciousness and “reduce” them to a complex interaction between mechanisms.

Introduction

1. “The mission of One Laptop per Child (OLPC) is to empower the children of developing countries to learn by providing one connected laptop to every school-age child” (<http://laptop.org/en/vision/mission/index.shtml>).
2. Dylan Hadfield-Menell, Anca Dragan, Pieter Abbeel, and Stuart Russell, “Cooperative Inverse Reinforcement Learning,” in *Proceedings of the 30th International Conference on Neural Information Processing Systems* (Barcelona: ACM, 2016), 3916–3924, <https://papers.nips.cc/paper/6420-cooperative-inverse-reinforcement-learning.pdf>.
3. Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge, UK: Cambridge University Press, 2016). Also see https://en.wikipedia.org/wiki/Community_of_practice.

4. Quoted in Walter Bender, Charles Kane, Jody Cornish, and Neal Donahue, *Learning to Change the World: The Social Impact of One Laptop Per Child* (New York: Palgrave Macmillan, 2012).
5. Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980).

Essay 1

1. Marvin Minsky, "Preface," in *LogoWorks: Challenging Programs in Logo* (New York: McGraw Hill, 1986), viii-xii.
2. A. Kee Dewdney, *The Tinkertoy Computer* (New York: Freeman, 1993).
3. Since this essay was written, a merged Meccano-Erector set is available. A nice website for history is <http://www.girdersandgears.com/>.
4. The example here is Kresge Auditorium, designed by Eero Saarinen, whose form is one-eighth of a sphere's surface.
5. Logo Computer Systems, Inc.

Afterword to Essay 1

1. Marvin Minsky, *The Society of Mind* (New York: Simon & Schuster, 1985), 18.
2. Seymour Papert, "Hard Fun," *Bangor Daily News*, 2002, accessed April 23, 2018, <http://www.papert.org/articles/HardFun.html>.
3. Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980).
4. See <https://gpblocks.org/>.
5. GP's usual colorful Tinkertoy-like "blocks" will be shown as "text on gray" for this chapter in black and white.
6. Quite a bit of the substance of this talk was later written up by Marvin in 1970 as his Turing Award Lecture called "Form and Content in Computer Science," published in the *Journal for the Association of Computing*

Machinery 17, no. 2 (April 1970), <http://web.media.mit.edu/~minsky/papers/TuringLecture/TuringLecture.html>.

Introductory Remarks to Essay 2

1. A fugue is a type of musical composition featuring two or more interweaving voices that take turns stating a musical theme, called the subject. It is a type of contrapuntal music, which consists of several independent melodic lines rather than a single melody and accompaniment. To hear examples of fugues, see the Well-Tempered Clavier (Johann Sebastian Bach, *Bach's Well-Tempered Clavier: 48 Preludes and Fugues for Piano* [London: New York: Music Sales; Amsco Music Pub. Co., 1972]) at <http://www2.nau.edu/tas3/wtc.html>, and The Art of Fugue by J. S. Bach (Johann Sebastian Bach, *Die Kunst der Fuge: BWV 1080: Autograph, Originaldruck* [Mainz; New York: Schott, 1979]).

2. Seymour Papert, "Powerful Ideas in Mind-Size Bites," in *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980), 135–155; Andrea A. diSessa, "Thematic Chapter: Epistemology and Systems Design," in *Computers and Exploratory Learning*, ed. Andrea A. diSessa, Celia Hoyles, Richard Noss, with Laurie D. Edwards (Berlin: Springer, 1993), 15–29.

Essay 2

1. Mathematics is broad and deep. It has a lot of major areas such as algebra and geometry. In this essay Marvin makes mention of a lot of other areas and concepts that may be unfamiliar to a lot of readers. He is trying to make a point. School has chosen a particular slice of mathematics, a fairly small slice. The choice is largely historical and in fact seems a little arbitrary. Marvin is suggesting other slices as the parts of math that schools could introduce. Recently we saw the dawn of mathematics related to computation, which has also introduced new slices. Marvin, in this essay, provides a lot of concrete suggestions for where our focus can be, even if some of it appears foreign right now.

2. At the time he was a computer science graduate student at MIT.

3. Minsky's suggestions are good areas for research.

4. Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006). Also see essay 1 in this volume.

5. Note Added 24 March 2008

The U.S. Department of Education issued a 90-page report proposing 45 improvements to math education. This report makes almost all the mistakes that I complained about in this memo. Its most emphatic recommendation:

A major goal for K–8 mathematics education should be proficiency with fractions (including decimals, percents, and negative fractions), for such proficiency is foundational for algebra and, at the present time, seems to be severely underdeveloped. Proficiency with whole numbers is a necessary precursor for the study of fractions, as are aspects of measurement and geometry.

The report says almost nothing about using computers except to suggest that learning to program may bring some benefits “if students’ programming is carefully guided by teachers so as to explicitly teach students to achieve specific mathematical goals.” Warning: the full report is likely to make your mind throw up. See it at <http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf>.

Introductory Remarks to Essay 3

1. Seymour Bernard Sarason, *The Predictable Failure of Educational Reform: Can We Change Course before It's Too Late?* (San Francisco: Jossey-Bass, 1991); Seymour Bernard Sarason, *Revisiting the Culture of School and the Problem of Change* (New York: Teachers College Press, 1996); Seymour Bernard Sarason, *A Self-Scrutinizing Memoir* (New York: Teachers College Press, 2003); and Seymour Bernard Sarason, *And What Do You Mean by Learning?* (Portsmouth, NH: Heinemann, 2004).

2. Jean Piaget, *Science of Education and the Psychology of the Child* (New York: Orion Press, 1970).

3. L. S. Vygotskiĭ, Michael Cole, Sally Stein, and Allan Sekula, *Mind in Society: The Development of Higher Psychological Processes* (Cambridge, MA: Harvard University Press, 1978); Lev Vygotsky, *Thought and Language*,

ed. and trans. Eugenia Hanfmann, Gertrude Vakar, and Alex Kozulin, rev. and exp. ed. (Cambridge, MA: MIT Press, 2012); and Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge, UK: Cambridge University Press, 1991).

4. Seymour Papert, "Hard Fun," *Bangor Daily News*, 2002, accessed February 12, 2018, <http://www.papert.org/articles/HardFun.html>.

Essay 3

1. "In everyday life, we routinely use terms like *Suffering*, *Pleasure*, *Enjoyment*, and *Grief*—but get stuck when we try to explain what these mean. The trouble comes, I think, because we think of such 'feelings' as simple or basic, whereas each one involves intricate processes. For example, I suspect that what we call '*Pleasure*' is involved with the methods we use to identify *which of our recent activities should get credit for our recent successes*" (Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* [New York: Simon & Schuster, 2006], 49).

2. Allen Newell, "The Chess Machine: An Example of Dealing with a Complex Task by Adaptation," in *Proceedings of the Western Joint Computer Conference* (Los Angeles: ACM, 1955), 101–108.

3. See <http://www.ou.edu/tulsa/education/faculty-staff>.

Introductory Remarks to Essay 4

1. Seymour Papert, "Foreword: The Gears of My Childhood," in *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980), vi–viii.

2. Marvin Minsky, "Music, Mind, and Meaning," *Computer Music Journal* 5, no. 3 (1981): 28–44, <https://www.musicmindandmeaning.org/>.

3. Marvin Minsky, *The Society of Mind* (New York: Simon and Schuster, 1986).

Essay 4

1. This is discussed more extensively in essay 2.
2. A popular view is fixed mindset vs. growth mindset. See Carol Dweck, *Mindset: The New Psychology of Success* (New York: Random House, 2006).
3. Marvin Minsky, "Thinking," in *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006), 215–253.
4. Marvin discusses reasoning by analogy in detail. See Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006), 206–209.
5. Just for fun search for "mnemonic examples" on Google and see the multitude of memory aids.
6. For examples of "debugging" applied to stilt-walking and juggling, see Seymour Papert, "Languages for Computers and for People," in *Mindstorms: Children, Computers, and Powerful Ideas* (New York: Basic Books, 1980), 95–119.
7. Dan Ariely, *Predictably Irrational: The Hidden Forces That Shape Our Decisions* (New York: Harper, 2008).
8. Minsky, *The Emotion Machine*.
9. These ideas connect to current discussions on "deliberate practice." See Anders Ericsson and Robert Pool, *Peak: Secrets from the New Science of Expertise* (New York: Houghton Mifflin Harcourt, 2016).
10. Minsky, *The Emotion Machine*, 81, 174, 210.
11. See the Scratch website at <https://scratch.mit.edu/> for an example of a well-moderated online community.

Introductory Remarks to Essay 5

1. Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006).
2. Seymour Papert and Cynthia Solomon, "Twenty Things to Do with a Computer (Artificial Intelligence Memo no. 248 and Logo Memo no. 3, AI Laboratory, MIT, June 1971).
3. Steve Lohr, "As Coding Boot Camps Close, the Field Faces a Reality Check," *New York Times*, August 24, 2017.
4. The Hour of Code is "a global movement reaching tens of millions of students in 180+ countries. Anyone, anywhere can organize an Hour of Code event. One-hour tutorials are available in over 45 languages. No experience needed. Ages 4 to 104" (<https://hourofcode.com>).
5. Pasi Sahlberg, *Finnish Lessons: What Can the World Learn from Educational Change in Finland?* (New York: Teachers College Press, 2015).
6. Seymour Papert, "Hard Fun," *Bangor Daily News*, 2002, accessed April 23, 2018, <http://www.papert.org/articles/HardFun.html>.

Essay 5

1. Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006), 2.
2. As discussed in the introductory remarks to essay 2, Marvin had taught himself how to improvise on the piano. His specialty was making up fugues in the style of Bach. For Marvin, learning to improvise fugues was a way to study the workings of the mind. In honor of Marvin's love for music and for the piano, drawings in the following section use examples from piano playing to concretize Marvin's ideas.

Introductory Remarks to Essay 6

1. See <http://illumium.org/calculus/integral.html>, running SAINT. For background, please see <http://logical.ai/auai/#demos>.
2. *Feedback* is a technical term; for an overview, see <https://en.wikipedia.org/wiki/Feedback>.
3. Alan Newell and Herbert Simon, like Minsky, were pioneers in establishing the field of AI and were professors at Carnegie Mellon University.
4. Patrick Winston and Dylan Holmes, “The Genesis Manifesto: Story Understanding and Human Intelligence,” forthcoming 2018, <http://courses.csail.mit.edu/6.034f/Manifesto.pdf>.

Essay 6

1. Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006), 271–275.
2. For discussions about making robots cooperate, see examples at <http://www.cs.cmu.edu/~robosoccer/main/>, [http://en.wikipedia.org/wiki/Flocking_\(behavior\)](http://en.wikipedia.org/wiki/Flocking_(behavior)), and <http://www.lalena.com/AI/Flock/>.
3. See <https://inventiveminds.xyz/essay6/links>.
4. See Patrick Henry Winston’s Introductory Remarks to Essay 6, page 121 of this volume.
5. Marvin also lists “Experimenting with ‘Rule-Based Systems’” as a category of project ideas but does not elaborate.

Afterword

1. Marvin Minsky, unpublished work, c. 1993.

