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Some thoughts on Andrea diSessa's *Five Powerful Ideas about Technology and Education*

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Let me begin by offering a subjective history of the influence of technological innovation on school mathematics over the last half-century, interpreting those 50 years of evolution through the lenses of a grade-school learner, a mathematics undergrad, a secondary-school teacher, a graduate student, and a university-based researcher.

And let me structure this account around a learning device gifted to me by my mother. She loved mathematics and instilled in me a habit of asking "WHWY …?"—or, in long form, "What happens when you …?" … add a number that's 1 greater … extend the idea to infinity … draw a parallel line that passes through the origin … substitute with a friendlier term …. The device continues to serve me well. On to my history:

I started high school in the mid-1970s, just after two older siblings had graduated. I had tracked their high-school studies with great interest, and I arrived at the door of the school eager to finally make use of my slide rule and personal copy of *Knott's Four-Figure Mathematical Tables*. No part of my siblings' studies had captured my attention more than these artifacts, each a nexus of so much insight into number and number operations. I have no idea how much time I'd spent exploring WHWY's with them in the years before reaching high school, but it was enough to prompt my parents to express concern at my obsession.

But, alas, the slide rule was not to be part of my official school mathematics experience, and *Knott's Tables* ceased to be used at the end of Grade 10. That's because hand-held calculators entered the high-school mathematics classroom at about the same time I did, and they were with me through my undergraduate experience. While I always thought these machines were a bit of a step backward, since they seemed to conceal the relationships and possibilities that slide rules and function tables so openly present, I appreciated their expansive new spaces of WHWY's. Being able to engage with sequences of rapid calculations pulled at my imagination. I recall vividly, for example, the first time I really "felt" exponentiation, as repeatedly pressed the "=" button after entering "2 × 2." It was exhilarating.

When I returned as a teacher to the secondary school classroom in the early 1980s, graphing calculators were all the rage. They enabled an impressive new class of WHWY's—ones that relied on many and varied simultaneous calculations rather than sequences of singular processes. Moreover, they communicated their results in both numbers and images.

By the late-1990s, those capabilities had been elaborated into tools that enabled WHWY questions that involve millions of movement-and-interaction-generating calculations on a computer screen, affording access to mathematical concepts and abstract insights that were just not available to me or my students only years earlier.

I could go on. But I'll pause here to wonder about diSessa's assertion (during his presentation) that "*the computer is a once-in-several-centuries innovation*." I suppose that's true, but I can't resist rearranging the words to assert that *the computer is several centuries of innovation at once*. Illustrated on the near-trivial level the experiences noted above, the computer incorporates-but-transcends all the technologies that framed and enabled my learning. All at once, the computer invites every type of WHWY that I've been able to ask—which is to say, the computer feels to me more like an iteration than an innovation.

What, exactly, is "computational literacy"?

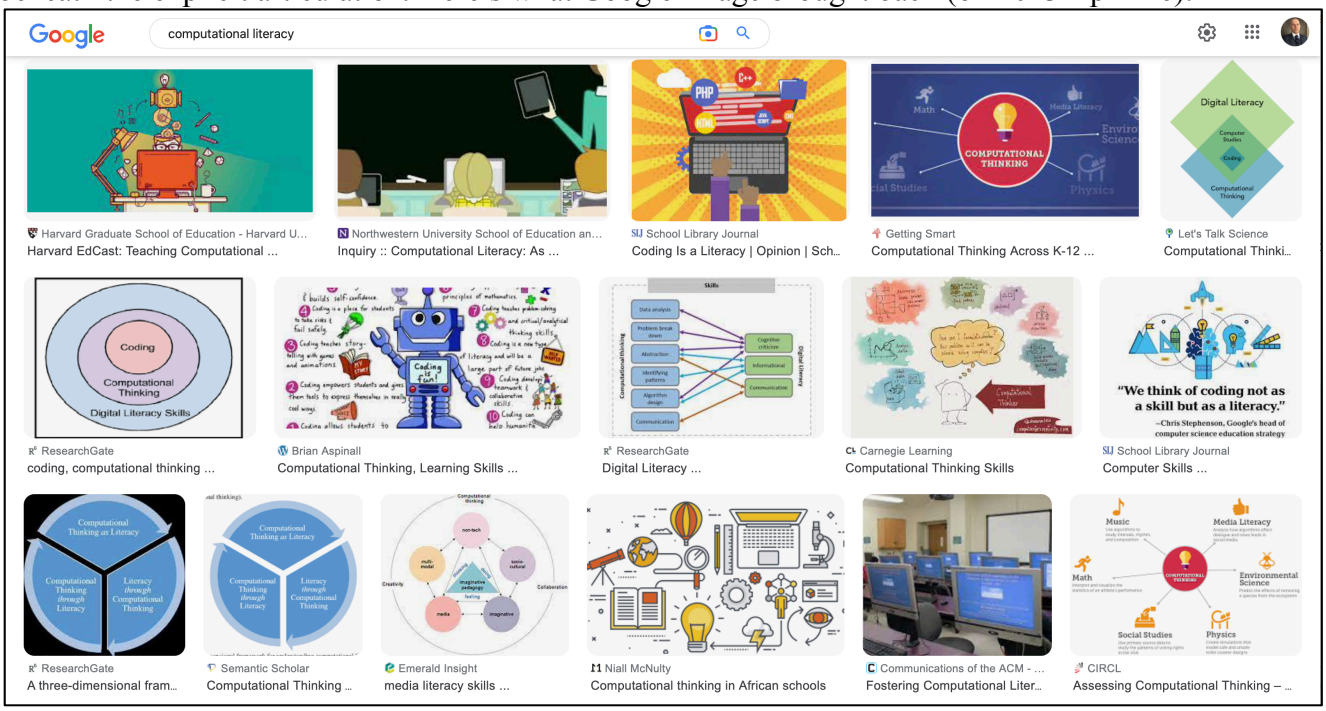
Why does that detail matter to me?

Well, it has everything to do with a personal struggle to make sense of what diSessa might mean by "computational literacy." In preparation for this response, I took multiple runs at understanding the construct (in addition to reading diSessa's 2018 article). I'll speak to three of them, starting with information provided by Wikipedia (on 2023 April 26):

> **Computational literacy** is a term that is used to describe the broad ability to apply computational thinking and awareness of the range, scope and limitations of computational techniques. It is distinct from the ability to perform math calculations by hand, instead anticipating that the actual computations will be performed by computers.
>
> A leading advocate of Computational literacy, Conrad Wolfram explains the difference as "The maths taught around the world today does not fit how it is used in the real world. Computation technology is more accessible than ever before, but no curriculum in the world assumes it exists. Instead, it is focussed on the mechanics of hand calculation, rather than the essence of real-world maths" Andrea diSessa has stated that "computers might fundamentally change learning."

Of course, it was reassuring to encounter diSessa's voice here. But I honestly couldn't extract much insight into computational literacy from this bit of text—other than to infer that we educators seem to be doing a lousy job at nurturing it. What I gleaned from Wikipedia, then, is that there's a tendency to define computational literacy in terms of something that modern schools aren't addressing adequately. Fair enough. Schools have always been more inclined to look backward than forward. They're notorious for focusing on literacies that are fitted to previous versions of society.

Hoping for a more broad-based glimpse into the construct, I turned to a favorite strategy of using an image search. This tactic rests on a no-doubt-fatally-flawed assumption that such searches can operate as cultural inkblot-tests—glimpses into what is operating in the collective unconscious, just beneath the explicit articulation. Here's what Google Image brought back (on 2023 April 26):



What might one pull from this? I see three main themes (and I acknowledge I'm likely missing some other obvious ones): Firstly, several images appear to confirm my initial impulse, reflected above, to index computational literacy to recent evolutions of digital technologies. Secondly, in several others, there seems to be a conflation of "computational literacy" and "computational thinking." And, finally, a couple of the images might be taken to suggest that computational literacy arises in the meeting of

various disciplines and/or other culturally privileged literacies (e.g., mathematics, music, and social studies). But, of course, none of that is especially surprising. Or, for that matter, enlightening. This image-search strategy usually affords some sort of unexpected insight for me, but in this case the results seem to served only as further confirmation that computational literacy isn't a broadly or readily understood notion.

That took me to my third strategy, which was ask ChatGPT. I agree with Noam Chomsky's assessment of this technology, as little more than automated and unabashed plagiarism, as so I anticipated its result would be a text version of my image search. Here's how it responded to the question, "What's 'computational literacy?'" (on 2023 April 26):

> Computational literacy refers to the ability to understand and use computers and computational tools effectively. It involves not just basic computer skills such as operating systems and software, but also the ability to think critically about the ways in which computing technology shapes our world, and to use computation to solve complex problems.
>
> At its core, computational literacy is about being able to read, write, and think in a world that is increasingly shaped by digital technology. This includes being able to use algorithms and code to manipulate data, as well as to critically evaluate the results of those manipulations.

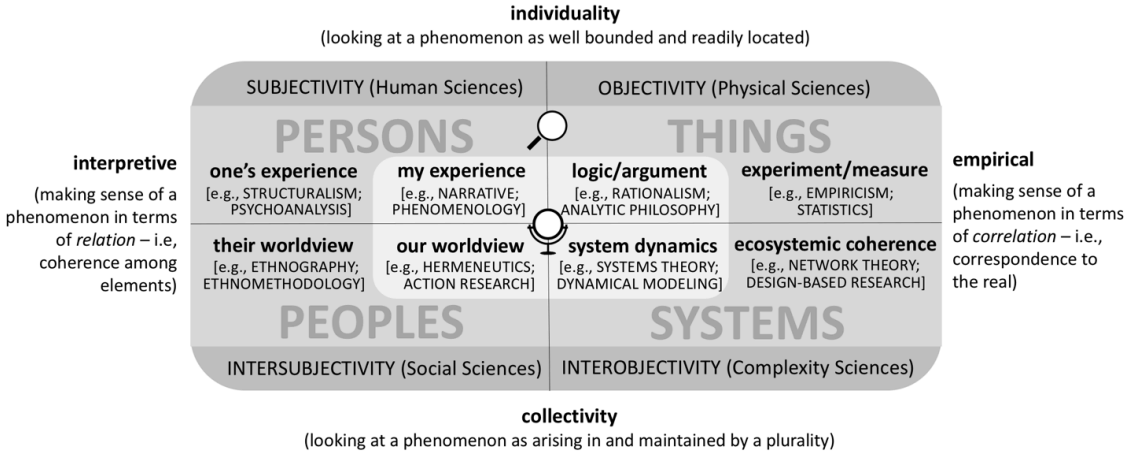
While still not completely satisfying, this description felt a bit meatier that I was expecting, especially that mention of "the ability to think critically" that's tucked amid the otherwise utilitarian elements.

I do have a point in all this. Cutting to it, if the construct of computational literacy is to have any cultural value, it seems to me that what is intended by the phrase must be readily accessible. And I confess that I don't quite get it, even after having paid close attention to multiple of diSessa's explications. Despite those, I find myself unable to reassemble a description that doesn't devolve into the word (or graphic) salads presented above. My default continues to be an extrapolation from my understanding of "mathematical literacy—which, in a nutshell, I understand as having to do with a fluidity of movement through a mathematized (computationalized) world … not just using/applying mathematical (computer-specific) knowledge, but recognizing, analyzing, evaluating, and/or extending, as appropriate in an interplay of not-necessarily-conscious knowing and doing.

What, exactly, is being presented?

Let me edescribe my struggle in understanding in another way.

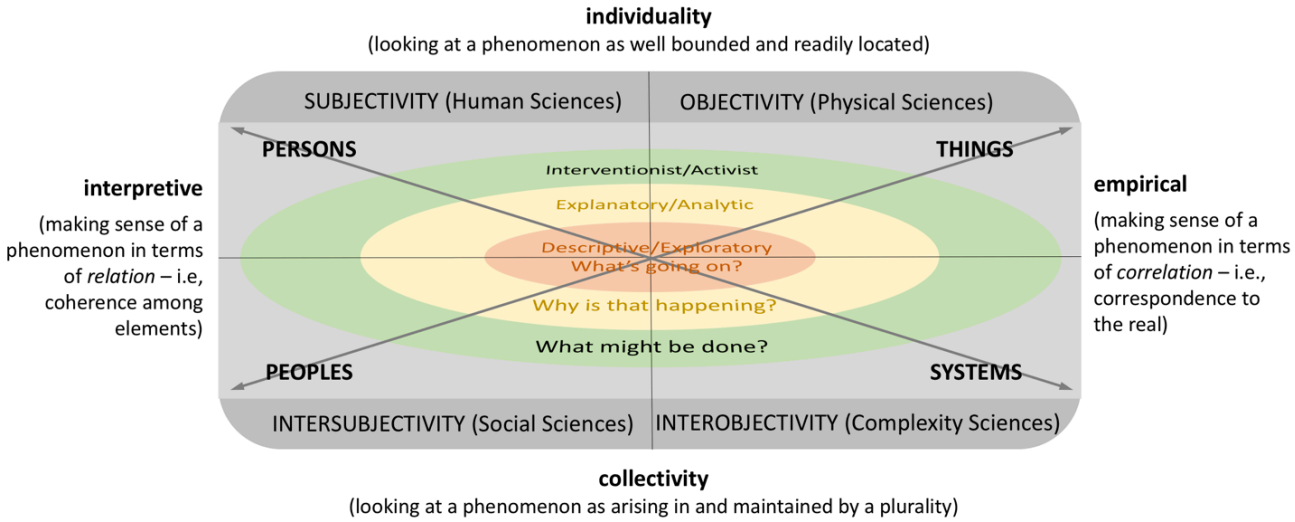
I'm in my 30th year of employment in the academic world, and one of the consequences of being around that long is that I've taught a good number of research methodology courses. The graphic below is a coarse representation of how I organize those courses. I'll defer detailed explication to another piece of writing (Davis, 2019), but I will mention here that my strong impression is that, if I wanted to research computational literacy, I'd probably be framing things in terms of phenomena and methodologies landing on the left side of the image.



But, yet again, that doesn't seem to tell me much. So, I'll move to the graphic below, which is intended as a sort of overlay to the one above. The nested regions in this image highlight three distinct types of research questions and researcher intentions:

- Explorative research that leads to descriptive reporting,
- Analytical research that generates explanatory commentaries,
- Activist research that are often presented interventions and manifestos.

Such intentions and question types, I believe, operate across most educational phenomena and most research methodologies.



I illustrate these three attitudes as nested because, in my experience, reports (i.e., descriptions of explorations) can stand alone in the published literature, commentaries (i.e., explanations and analyses) typically begin with reports but extend them, and manifestos (i.e., interventions and calls to action) include and transcend reports and commentaries.

And that takes me to a suspicion that, I might be misreading/mishearing diSessa's account of computational literacy. My desire for clearer definition tells me that I'm probably forcing his presentations of the construct into a descriptive report, and it strikes me that the notion (and diSessa's presentations) might be better considered as commentary, perhaps even manifesto.

Am I hearing correctly?

So, I'll run with that thought—that is, that the construct of "computational literacy" is in essence a call to action. Accepting that computational literacy will be "close to universality" (diSessa, 2018), what should we be doing? DiSessa has (2018) has suggested a starting place:

> Get to know computational media as deeply as you can … the most epistemologically rich computer systems you can find. By "epistemologically rich," I mean having legitimate—but likely as-yet unrealized—consequences for the mathematics we can experience and might teach. (p. 39)

Clearly, that's sensible advice, and it feels like it's driven by the sort of optimism that we educators must occupy. In particular, I very much appreciate that the gaze here is on an as-yet unrealized future, not an established past.

But, at the risk of raining on the parade, the call was published five years ago … and, given the ever-accelerating pace of technological development, I'm mindful that the world of formal education

has almost certainly fallen even further behind. Curriculum, especially, doesn't seem inclined to budge—except, perhaps ironically, around the topic of coding, which is doubtless at the core of the conflation of computational thinking and computational literacy.

Much as I don't want to sink into pessimism, I do feel a need to call for tempered optimism. This morning—on 2023 October 16, almost six months after the meeting at Brock—one of the top stories in my newsfeed was titled, "AI could spur an economic boom. Humans are in the way" (Omeokwe, 2023). Even after taking into account a likely lean toward the sensational here, I'd be lying to say I'm not dismayed at the prospects for computational literacy in light of where things seem to be going. Might the window of opportunity for this great idea have closed?

It should be clear by now, given my ongoing struggles to get a handle on computational literacy, that I'm not a quick study. That said, I want to mention that I did begin to feels some clarity as I read diSessa's (2018) focused commentary on Jeanette Wing's take (or *mis*-take?) on the topic. I'll abbreviate my interpretation by offering that Wing's account feels a whole lot like the authoritative-but-ultimately-incoherent ChatGPT explanation pasted above. Her version of computational literacy is a lasagna of HOTS (higher-order thinking skills), mental discipline, equity, liberation, competitive advantage, vocationalism, and inclusivity. DiSessa has offered a decidedly clearer vision.

Pushing aside my anxiety that the window of opportunity on that vision may have been missed, on the matter of what we as educators should be doing around computational literacy, I'm landing on the thought that our most important work is to avoid being "Winged." And, for that, I thank diSessa. As much as I struggle with the construct of computational literacy, I recognize it as a necessary part of formal education's obligation to help its society maintain fitness with the evolving world.

References

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