Book Review

Changing Minds: computers, learning, and literacy
ANDREA A. DISESSA, 2001
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296 pp.
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As things in motion change where they are in space, so do people who are learning change by the workings of their minds and actions. The interpreting of change, both physical and personal, permeates this book and the author's educational research that it articulates. *Changing Minds* argues that interpreting these changes is something that everyone has the capacity for doing, and compellingly demonstrates how 'flexible computational media' can enhance their means and access for doing that. These media use a language whose syntax is simple enough to be learned by anyone, as well as a framework within which programs written in that language can execute and interact with one another. Effective use of these media requires a 'computational literacy' analogous to textual literacy. As 'knowing how to read' expands one's horizons and capabilities manyfold, this new literacy can pervade people's lives, making possible their participation and growth in new social, material, and intellectual cultures.

While these ideas seem to cantilever beyond the expectations of conventional education, they are supported by detailed observations of schoolchildren making their own computational interpretations of motion. For example, Sheena, a sixth grader, worked with software commands that represent speed as an executed change in position and represent acceleration as an executed change in speed. She drew on that pattern to invent her own command, 'oomft,' to change acceleration. She then tested how this new command affected onscreen motions. The computational medium—the 'Boxer' software that is core to diSessa's research—allowed Sheena the flexibility to define, test and explore her own emerging understanding—one that faithfully describes the abrupt changes of non-constant accelerations.

DiSessa believes that the computational medium of Boxer is conducive to expressions of original ideas such as Sheena's:

> *Computational media can foster children's having and developing their own good ideas by being open at every instant to the child's changing and extending what is there. Sheena wrote one extra line of code into a prewritten program and entered a personal, new world. Having an opportunity to be creative every instant means that every person, sooner or later, can be really creative. (p. 51)*

Personalized, creative student work is often viewed as counterproductive to conventional science learning, being seen as harboring 'wrong' ideas that

allegedly inhibit conceptual mastery. DiSessa's research challenges this assumption. His investigations delve into the deep sense about physical motions that people develop from daily experience. He shows how integrating that intuitive knowledge into education gives learners access to personal experience in making sense of things or questioning surprising behaviors. He believes, as do I, that intuitive knowledge is not reducible to 'right' or 'wrong', to a mathematical formula, or even to an explicit description in words. Ambiguity, in these terms, can be an asset for conceiving and trying diverse possibilities that sustain new personal knowledge and lead to what he calls 'committed learning'.

DiSessa notes, 'Committed learning reminds us that education is not just a technical accomplishment. It is about designing the lives of our children' (p. 87). DiSessa sees a place for 'design' that promotes the spontaneous outbreak of deepening and committed engagements. 'Design' is not controlling; it is enabling. The role of 'design' is to open up multiple activities by which each student can form their own ways of working. The evidence that a 'designed environment' is productive lies in what the students do and initiate; the multiform growth of their commitment.

This perspective on design directs DiSessa's work with 'Boxer', a computational medium for education. (See FIG. 1). Boxer's roots include the educational programming language Logo. Logo elements borrowed by Boxer include an onscreen 'turtle' that one tells to move by one-word commands with an argument, such as 'forward 20' or 'left 45'. Unlike Logo, Boxer adds a program organizer, the 'Boxes' that are rectangles containing text, data, or programming commands. The containment relationships between boxes reflect the hierarchical structure of a document, or the scope of variables within a program. Boxer is not a 'version' of Logo; it is a programming environment which supports almost everything that Logo supports, and more.

DiSessa depicts Boxer's educational power through what children experienced while interacting with it. Carol and Ming were working with a 'microworld', where a turtle could be directed to move independently on an also-moving flatcar. A fixed view showed the turtle's net motion, combined from the separate motions of turtle and flatcar. Before each trial, the children discussed how they thought the motions would combine. One combination was particularly challenging: the flatcar goes clockwise while the turtle moves counter-clockwise. Ming supposed the motions would cancel, leaving no net motion for the turtle. Holding her index fingertips opposite each other and moving them in a counter-circling sense, Carol excitedly realized that the motions only partly cancel: 'It's going to make a line!' (p. 194). Working out the turtle's back-and-forth motion involved combining Ming's idea of canceling and the additive compositions they had already done in Boxer. Their thinking about motion changed, not from being told how motion works, but through building personal experiences with representing it.

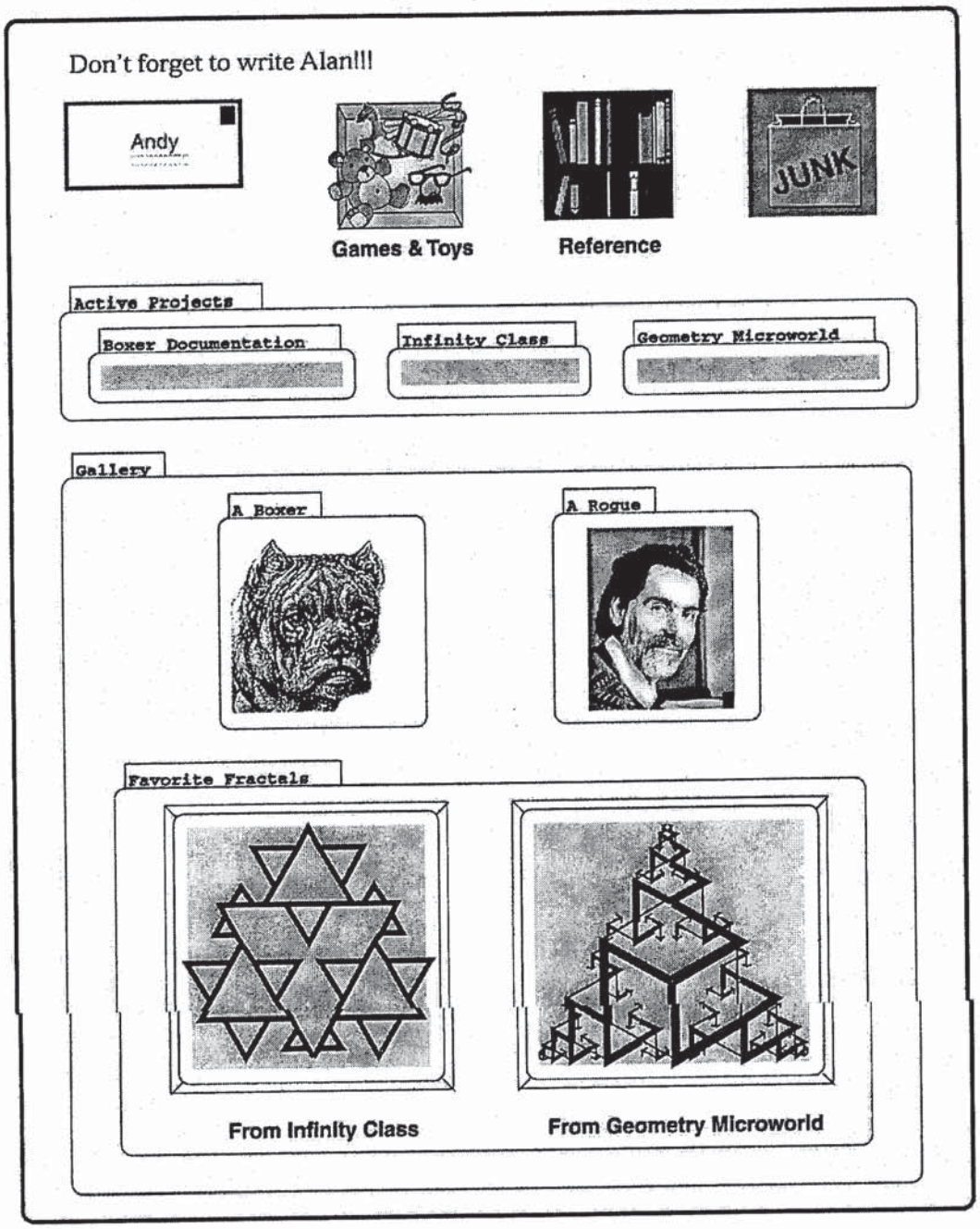

FIG. 1. Boxer interface. A Boxer 'world' contains boxes, text and pictures. Boxes may be full-screen (the top-level rectangular outline shown here), open (such as *Gallery*), or closed (small, gray boxes or icons like the envelope-shaped correspondence box). Boxes also organize programs and data objects. (Image courtesy of Andrea DiSessa, reproduced with permission.)

Drawing on observations of children's learning, DiSessa advocates a needed cultural revolution in the way we approach educating students with computers. According to DiSessa, committed learning thrives in any area that learners have begun to make their own; school instruction, on the other hand, typically prevents this kind of ownership by sequencing students through pre-set topics, which leave no room for intuitive exploration.

DiSessa decries these 'efficient' school practices, which are motivated only by outward signs of information output and lose sight of deeper processes that come into play when people are genuinely engaged. Schools' test-narrowed emphases press out a subject's diverse textures, just those handles that can become learners' means for robust understandings.

DiSessa calls for a revolution in educational practice and suggests that Boxer lead the charge. DiSessa argues that, as a computational medium easy enough for anyone to learn, Boxer is usable for more than motion exercises. It already accommodates graphics, word processing, and accounting, and he envisions Boxer becoming a ubiquitous tool with expanding uses.

This revolution—by his admission—faces resistance from the inertia of a far larger culture of educational practice. 'Education ... is not a fertile ground for new ideas ... Changing it is bound to be difficult' (p. 228). He queries why Boxer's acceptance is so limited, while the World Wide Web is pervasive, even though it is not optimal as a dissemination medium for knowledge.

What DiSessa does not appear to acknowledge is that the pre-eminence of the Web has to do with wide adoption, which drives its rapid evolution and makes the Web the de facto 'computational medium' regardless of its seeming inappropriateness for the task. One might ask why a 'more optimal' approach such as Boxer has not achieved such ubiquity. I think this is because, like the Web, Boxer must evolve—from a tool intended to drive cultural change into a product of a broad and diverse culture, driven by the needs of that culture instead of serving to initiate a culture.

I believe Boxer's most important contribution is the description of the principles and rationale of 'computational media' upon which Boxer is founded. In arguing for the educational promise of computational media, DiSessa's commitment anchors in the media, such as Boxer, and becomes tinged with disappointment. This tone contrasts with Papert's optimism of 20 years before (1980), in envisioning Logo as a computational extension of the working materials with which children can 'tinker' while developing 'powerful ideas' of their own. Papert sought to supplant instructional formalisms by offering 'concrete' motions of a real robot turtle, and a virtual one, programmed by the children. Along the way, children experienced themselves learning through 'debugging' their programs, not by getting something 'right' or 'wrong'. DiSessa, by contrast, is less optimistic about the acceptance of this mode of teaching in the educational community. He shows that children design personal graphics and collaborate easily while working with the fully virtual Boxer displays, but despairs that these results do not resonate with what our educational culture desires and promotes.

Understanding how things work, by developing one's own experimental understandings, is still a new way of learning science. Galileo—whose

motion theorems open DiSessa's book—argued for experiment as a test of Earth's motion, by describing a playful 'microworld' of his own. The moving ship represented the Earth (or di Sessa's flatcar) and its passengers (like us on Earth, or the flatcar's 'turtle') demonstrated their oblivion to that steady motion:

> *Shut yourself up with some friend in the main cabin below decks on some large ship, and have with you there some flies, butterflies ... have the ship proceed with any speed you like, so long as the motion is uniform ... You will discover not the least change in all the effects ... the butterflies and the flies will continue their flights indifferently. (Galileo, 1632)*

That playful involvement, resonating in DiSessa's book, also invites readers into changing what they know about learning.

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NOTE

Boxer is available online (for Macintosh users only) at http://www.soe.berkeley.edu/boxer/. The site also includes tutorials, sample Boxer curriculum, contact information, and online references (including chapters 1 and 2 of the book).

REFERENCES

GALILEO, G. (1632) *Dialogue Concerning the Two Chief World Systems*, trans. S. Drake, pp. 144–145 (Berkeley, CA, University of California Press, 1967).
PAPERT, S. (1980) *Mindstorms: children, computers, and powerful ideas* (New York, Basic Books).

Book Review

The Digital Divide, Facing a Crisis or Creating a Myth?
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This book brings together some of the key documents relating to the digital divide in the USA. In addition to summaries of the important reports