

Some Humbling Lessons from a Reconstructible Computational Medium

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For over 20 years I have been investigating interest-based learning and I first started on this path largely because of what Boxer seemed to afford students and their expressive needs in the classroom. In this brief essay, I reflect on my early observations of students' interest-driven pursuits in Boxer and the research those observations have spurred, (Azevedo, 2006, 2011, 2013) and distill some key lessons from these experiences. In particular, I focus on how empowering students with a reconstructible computational medium such as Boxer can lead to humbling insights into our own learning and development as researchers and educators, as well as to larger questions regarding knowledge production and the work toward a socially just world.

Two Examples

There are many examples of students' interest-based participation in Boxer-based classroom activities and I draw on two such instances to illustrate my arguments. Both examples come from the same instructional contexts—namely, an experimental after-school summer program that lasted 6-weeks, met twice a week in 3-hour-long classes divided into two periods. The class had 10 students of mixed age and course grades were reported back to students' home schools (for credit).

The subject matter of the course centered the role of *representational forms* (e.g., Cartesian graphs, topographic maps, lists, tables, diagrams, vector fields, etc.) in the practices of science and mathematics. Rather than teaching students the canonical representations of technical disciplines, however, we asked them to invent, critique, and iteratively refine their own representations of various phenomena. In a typical activity, for example, students worked with crayons and paper to design representations of moving objects, physical terrain, and tornados. In the computer lab, students worked in small groups on a variety of Boxer-based activities, the bulk of which focused on scientific image processing. Scientific image processing is a kind of scientific visualization software and it is therefore a prototypically representational technology in that it presents visual displays as surrogates for data (Friedman & diSessa, 1999). Figure 1 shows the Boxer scientific image processing environment and its basic toolset (i.e., zoom tool, min-max settings and palettes for data rendering, and data inspection tool), with a rendered image of galaxies taken by the Hubble telescope.

Within this context, the following cases of student interest-driven participation took hold. (A full description of students' works in the course, as well as reports on the larger context of this research endeavor, can be found in diSessa et al. (1991), Sherin (1997, 2000), Madanes (1997), Azevedo (1998, 2000), Granados (2000), diSessa & Sherin (2000), and diSessa (2002)).

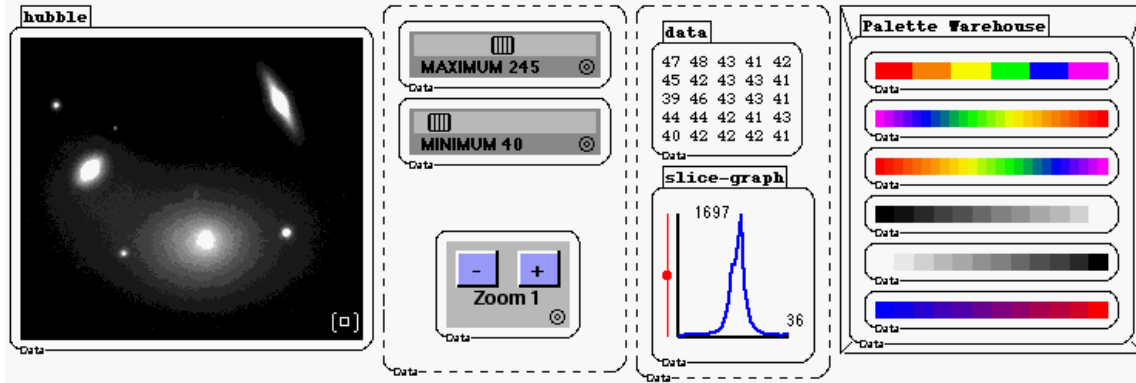


Figure 1. The Boxer-based image processing environment and tools. The rendered image of galaxies is from the Hubble telescope.

Case 1: Galaxies Galore

Throughout the course, Dean (9th grade) showed a strong artistic bent in his approach to course activities. For instance, when representing various terrain forms with paper and pencil, Dean applied some free-drawing techniques that he had practiced in art classes elsewhere. In the lab, Dean teamed up with Peter (8th grade) and together they engaged the proposed activities and Boxer in unique ways.

Finding “interesting” color combinations for a palette appeared to be a particularly motivating activity for both Dean and Peter. In any given software-based activity, they could be seen creating and refining a number of palettes, which they often saved. Figure 2b shows the palettes that Dean and Peter saved during both the *Moon* and *Hubble* activities.

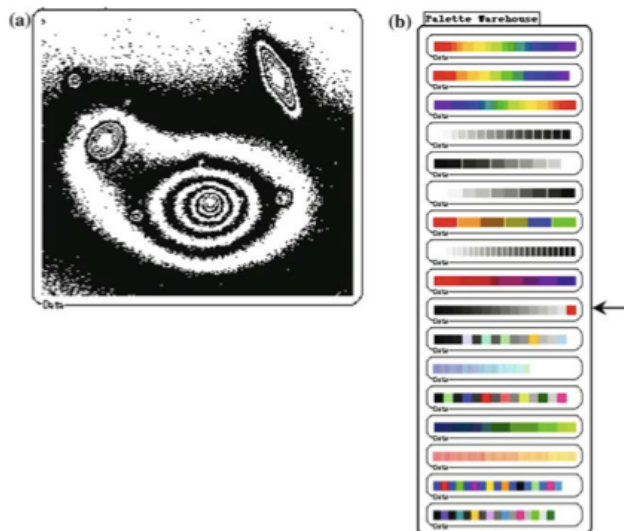


Figure 2. (a) Dean and Peter’s “zebra palette” rendering of the Hubble image; (b) The duo’s extensive palette work and the “special” palettes they generated along the way.

Perhaps as a natural extension to the insistent palette creation work they carried out since the early moments of that day’s activities, when working in *Hubble* Dean and Peter decided to introduce in a palette a color that strongly contrasted with its neighbors. Because at that time Boxer’s Palette Making Tool did not support arbitrary, user-controlled interspersing of colors, Dean and Peter had to work around tool limitations in order to achieve the desired effect. Because the students accomplished their goal on their own, they must have spent some time “poking around” until they finally figured out how to flip data boxes and edit individual palette colors.

Having succeeded in creating the unusual palette (see arrow, Figure 2b), Dean and Peter rendered the galaxy-and-stars image that was the object of study. Noticing that the procedure resulted in a strong feature highlighting effect, they started anew, laboriously arraying on a palette a number of selected color elements, each of which contrasted sharply with its neighbor. Eventually, the students created what we came to call the *zebra palette*—a sequence of interpolated, highly contrasting color elements. Zebra palettes have the property of highlighting boundaries between ranges of data values in an image (Figure 2a). In conventional scientific terms, a zebra palette creates contour regions.

Crucially, zebra palettes afforded Dean and Peter discovering aspects of the Hubble image unknown to teacher and classroom researchers. Specifically, because of the high contrast between data range boundaries that the unusual palettes created, the duo uncovered “hidden” galaxies that had not been detected by the teaching team.

Case 2: Perceptual illusions

Despite the course’s focus on representational design, as a final project Cathy and Carl (9th grade) investigated perceptual illusions caused by certain geometric displays. Their choice was motivated both by a suggestion the teacher had made to the group and by Carl’s own interest in perceptual illusions.

With help from the teacher, Cathy and Carl approached the problem by consulting a book on the psychology of perception. From the book, they picked an illusion commonly known as “the café wall illusion” (Figure 4a). To simulate the illusion, the students requested that we made some additions to our Landscape Construction Kit (LCK, Figure 3). Briefly, the LCK allows one to edit graphic displays, much in the way drawing programs work. In the context of the image processing environment, however, the editing actions in the LCK result in changes to the underlying data, which are meant to represent altitude information.

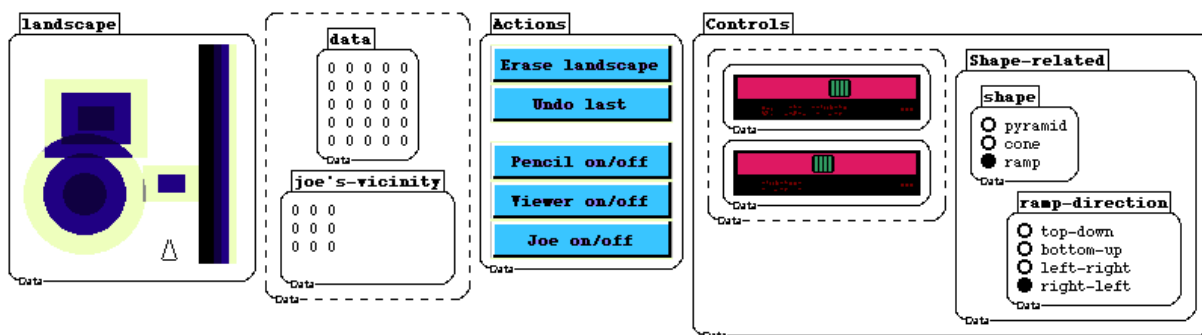


Figure 3. The Landscape Construction Kit, as the research team had originally implemented it.

We carried out the modifications that Carl and Cathy requested and from that point on they began their work, first by creating/editing the illusion display. Then, they proceeded to vary different parameters of the illusion. For instance, they wondered whether the illusion effect is observable in color renderings of the image, as well as in black and white versions of it. As their investigation progressed, however, Carl and Cathy decided that they needed to repeatedly edit multiple parameters of the display, starting anew each time. The new requirements led students to judge that the LCK adaptations we had implemented were not up to the task; briefly, using the tool entailed a cumbersome and slow editing procedure.

So Carl implemented his own tool, in his spare time, using a copy of Boxer that he installed in his home computer. Carl's program used pieces of a simple square-stamping procedure (Figure 4b) that he had previously coded, as a "side-task" he initiated during the very first computer-based activity in the course. On that occasion, Carl, Cathy, and Beth (the protagonist in the next vignette) were working together, and collaboratively they explored some basic graphics functions of Boxer.

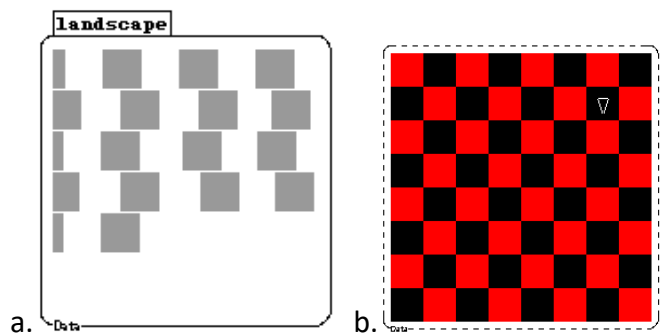


Figure 4. (a) Dean's original experimentation and implementation of a square-stamping procedure in Boxer; (b) The Café Wall illusion, as implemented by Carl and Cathy.

With the new tool in hand, Cathy and Carl were again ready to proceed. In a more-or-less systematic way, they resumed experimenting with various attributes of the image, editing the code as needed and saving versions of each of their experiments. During project presentation, they developed a convincing explanation regarding the psychological and physiological basis of the illusion, and remarked on some of its aspects that they still could not understand.

Analysis: Key Humbling Lessons for Educators

Focusing on the similarities and differences across the cases, we distill three specific lessons for our practices as educators and researchers:

1. What emerges from students' use of the medium cannot be practically predicted.

By making use of Boxer's open, reconstructible interface and its programming capabilities, in both episodes students initiated their own idiosyncratic activities and deviated from the proposed ones. I call these student-initiated activities *personal excursions* and

evidence shows that students learn much from them. Importantly, given their interest-based nature, personal excursions are highly idiosyncratic and cannot be practically predicted; i.e., students will go in nearly infinite directions. Students' inventiveness and creativity with the medium, therefore, humbles us in that they extend beyond foreseen intentions and uses.

2. Students will (almost promptly) produce knowledge beyond educators' current understandings.

Students' personal excursions in Boxer will quickly lead students into "knowledge territory" that clearly escapes educators' expertise/grasp, disciplinary or not. Dean and Peter's uncovering of hidden galaxies through flexibly manipulating the medium's interface is a stark example of this point, but others exist as well (Azevedo, 2006). This is again a humble reminder of students' competencies and inventiveness in the presence of an extendible, open computational medium.

3. As with any other forms of literacy, the cumulative result of the medium's use is likewise practically unpredictable.

This is a direct upshot of arguments 1 and 2 above. That is, personal excursions resulted in a growing, cumulative knowledge-base with a "life of its own," again impossible to predict a priori. We are thus humbled by the possibilities that new *infrastructural* literacies (such as Boxer) create.

I will further elaborate on each of these during the presentation, and argue that together they raise important issues regarding the political dimensions of literacies, particularly those at the heart of capitalist production.