Technology for Learning: Moving from the Cognitive to the Anthropological Stance

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Abstract: Most current research in educational technology proceeds from a philosophical stance based upon cognitive science. Typical questions implied by this stance include: How do we help students develop more accurate or fruitful knowledge structures? How do we overcome misconceptions in science or mathematics? How do we train skills more efficiently, employing what we know of human memory and learning? How do we encourage the growth of metacognitive skills? While such questions are interesting, this paper argues that they are ultimately peripheral for the purposes of designing effective educational technology. Indeed, the "cognitive science stance" tends to ignore or take for granted issues that are, in fact, much more central and productive in guiding design. These are questions rooted in anthropology, not cognitive science. They include: How and why do children make friends? What features of physical settings encourage (or discourage) the development of children's interest? Why, and in what situations, do children develop intense intellectual passions and obsessions? This paper discusses the sorts of questions that designers of educational technology need to ask in order to make progress beyond the confines of cognitive science research.

Introduction

Educational technology research—like any other sort of research—tends to begin with a set of (often unstated) philosophical assumptions; these assumptions in turn guide the nature of questions that researchers feel encouraged or permitted to ask. In the current intellectual and political climate of educational technology, it is fair to say that the dominant philosophical assumptions are derived from the (by now) half-century-old field of cognitive science. Indeed, for many researchers, there is a natural tendency to blend (if not equate) the notions of "applied cognitive science" and "educational research".

This paper will, in fact, challenge the merits of cognitive science as a disciplinary foundation for educational design. Nonetheless, before proceeding further in this discussion, it would be worthwhile to illustrate the central concerns and findings of the "applied cognitive science" approach. Probably the best exemplar of this approach can be found in the widely cited National Research Council report How People Learn [2000], which has justifiably been regarded as a landmark publication in the learning sciences. Several "key findings" reported in that book are summarized in a smaller companion volume [NRC 1999, ch. 2], and can be presented here as an illustration, in distilled form, of the applied cognitive science approach:

Key Finding #1: Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

Key Finding #2: To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

Key Finding #3: A “metacognitive” approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

It is worth reflecting upon these key findings, to see what they imply for the pursuit of design in educational technology. A designer responding, for example, to the first finding might attempt to create a computer application that identifies children's misconceptions about (e.g.) physics, and that then presents children with examples whose purpose is to challenge or contradict those misconceptions. A designer responding to the second finding would plausibly focus on creating intelligent educational (or tutoring) applications that (a) represent knowledge structures characteristic of expert thinking, (b) interpret or diagnose children's knowledge structures, and (c) compare the two in order to see what material or ideas to convey next. A designer responding to the third finding might well focus on the pace of presentation of material: perhaps we might design an application that, from time to time, encourages children to reflect upon their own progress, or to identify their own learning styles.
These suggestions do not, of course, exhaust the realm of "applied cognitive science" design for education, but they are typical of that approach, and directly responsive to the key findings reported in How People Learn. More broadly, these types of design approaches are now generally regarded as "scientifically based" (or, in another popular phrase, "evidence-based"), in that they are responsive to well-designed, reliably reported experiments investigating human learning and cognition. Identifying such approaches as "scientifically based" tends to imply, by contrast, that alternative approaches to educational technology design are unsound, vague, sloppy, irrational, or counterproductive.

The remainder of this paper is devoted to the argument that this "cognitive science based" approach to educational technology design is, at best, radically incomplete. To preview the argument at this early stage: the point is not that the research behind (e.g.) How People Learn is in any way flawed or unreliable. The point is rather that this research is ultimately peripheral to the real challenges of education, and to the most interesting and important dimensions of educational design. The key findings quoted above are not so much wrong, as simply not all that important. To design productive, meaningful new technologies and systems for learning, we will have to ask questions that are presently invisible to the cognitive scientists.

What follows, then, is an expansion of this argument. The goal here is to suggest an alternative theoretical perspective—one informed by cognitive science, and consistent with its findings, but based largely in children's anthropology. The anthropological perspective tends to highlight different issues in children's intellectual development. It inquires about friendships, role models, family dynamics, peer pressure, physical settings, neighborhoods, rituals, intellectual passions and obsessions, and patterns of day-to-day activities (among others). It seeks to ground technological design in response to these factors, and thus tends to view "technology" as an interwoven system of material and computational artifacts (rather than, e.g., a single particular computer application). It tends to de-emphasize classroom experience, if only because that experience is no longer identified as the primary or default source of children's learning. It is less dependent on laboratory findings and computational models of learning, and thus more alert to the crucial elements of intellectual biography that are of necessity ignored or suppressed in the laboratory.

The following (second) section of this paper begins by taking a closer look at the origins, occasional strengths, and numerous limitations of the cognitive science approach to design in educational technology. The goal here is affirmatively not to critique any particular research project or finding, but rather to question the reflexive identification between "cognitive science" and "scientific educational research". The third section presents a variety of contrasting anthropological themes, based in literature from that field, that highlight important questions for the design of novel educational technology. The fourth and final section suggests a sampler of potential design projects and approaches emerging from anthropological questions. Along the way, throughout the paper, we will make use of occasional illustrative examples from our own work, and that of others.

Cognitive Science as an Incomplete Foundation for Educational Design

In order to re-examine the role of cognitive science in education, we would do well to view the discipline as itself a type of intellectual culture—one that (as all intellectual cultures do) highlights certain questions, or types of questions, while suppressing others. For the purposes of our argument here, we can group our observations along three axes: namely, the cognitive portrait of intellectual growth and development, the cognitive stance toward educational infrastructure and institutions, and the cognitive view of intellectual motivation. All of these various dimensions are in fact tightly interwoven—there is a certain (probably laudable) internal consistency within the cognitive science culture. Still, for the sake of clarity, we can disentangle elements of each dimension for individual discussion.

Intellectual Growth and Development. In general—and at the risk of only a bit of caricature—the cognitive portrait of intellectual growth and development is one derived from a natural mapping between intellectual performance and prominent characteristics of traditional (von Neumann) computational systems. Thus, a cognitive account of education will stress such activities as problem solving; skill acquisition; retrieval, recall, and reconstruction of factual material; mental models of complex structures or dynamical phenomena; and metacognition. This is of course only a partial list, but it is representative of the traditional core of the field.

The computational roots of the cognitive tradition are worth noting here. A view of problem solving rooted in algorithmic research on search strategies will tend to ask questions such as: what kind of search strategy is the student using to solve a problem (e.g., in solving an integral equation)? How flexible are the student's strategies? What parameters (e.g., depth of search, pruning of alternatives) characterize effective searching? Likewise, a view of factual retrieval rooted in computational models of memory will focus on questions such as precision (relevance) and recall (coverage) of the memory process; training and testing schedules that lead to more effective retrieval; elaborative structures (such as analogies) that aid retrieval; and so forth.

More recently, the landscape of cognitive science has expanded, with encouraging prospects: there has been an increased attention to hitherto underexplored topics such as the role of mental imagery in intellectual performance [Mathewson 1999], gestural and "whole-body" aspects of learning and cognition [Nemirovsky et al.]
Studying a topic such as informal conversations—path of least resistance: direct instruction is, after all, relatively easy to implement, alter, observe, and measure. Conversations, or metacognition in the context of free exploratory play. Still, classroom research represents a solving, skill acquisition, and so forth) and the structural settings of schools and classrooms. One might study underlying structural assumptions about the nature and settings of learning and development. For the most part, educational cognitive science, as described in the preceding paragraphs, are accompanied by a number of cognitive science research in education devotes its attention to direct instruction as a motor for human learning. This is not to say that the proposed low-level computational structures (search strategies, rule bases, semantic networks, and so forth) are themselves the targets of direct instruction, though that is sometimes the case; rather the style of research focuses on settings in which a teacher (human or computer) is placed in the role of moving the student from one intellectual state to another. As a corollary, a disproportionate level of attention is paid to classroom settings in the cognitive science literature on education.

In principle, there is no necessary connection between the intellectual focus described earlier (problem-solving, skill acquisition, and so forth) and the structural settings of schools and classrooms. One might study (e.g.) skill acquisition in vocational situations [cf. Rose 2004], or problem solving as experienced in informal conversations, or metacognition in the context of free exploratory play. Still, classroom research represents a path of least resistance: direct instruction is, after all, relatively easy to implement, alter, observe, and measure. Studying a topic such as informal conversations—where there are no control groups to be found—necessitates an approach closer to ethnography or anthropology (a point to which we will return).

A structural emphasis on classroom instruction carries with it a variety of related (often unstated) structural assumptions about how and where learning occurs, and how it is to be studied. For instance, the disciplinary domains of cognitive educational research rarely stray beyond the boundaries of school material. It would be unlikely to study skill acquisition for idiosyncratic topics, even when those topics may be of some historical relevance (how do children learn to tend gardens in family settings?), personal meaning (how do children acquire skill in caring for pets?), or cultural resonance (how do children develop and judge performance in skateboarding?). Likewise, by assumption, most research focuses on learning that takes place at designated times and locations, rather than (say) intermittently over the course of months or years; and most research focuses either on individual learning (e.g., as measured by tests) or learning in the company of a restricted cohort of age-mates. All of these implicit assumptions may appear natural when the focus is on classrooms; but they all place strong and to some degree arbitrary restrictions on what is permitted under the aegis of "educational research".

In this context, there is still one more structural assumption to be mentioned: because of the cultural emphasis on "scientific evidence" that has come to dominate the cognitive approach to education, there are strict constraints placed on the design process for those who would create novel educational artifacts. In particular, the constraints of research strongly point designers toward creating, and studying, a single individual system or artifact that permits of direct experimental assessment. Often this takes the form of a specific computational system or curricular intervention; and the standard form of research is to compare the experimental student (using the system) with the control student (who doesn't use the system).

It is rarely acknowledged how arbitrary and impoverished this single-intervention stance can appear to those who study the history of technological design. It is much more likely for technology to be experienced as a widespread ecosystem of innovations—a collection of tools, devices, and techniques that collectively alter personal experience. To take an example, one might ask what historical effect "the printing press" had on the children of the sixteenth century, but such a question would have to take into account the growth of printing-related professions (such as bookbinding), the growth of a paper industry, and the advent of new literacy-based professions such as financial accounting, to name just a few factors. In a similar vein, a present-day educational designer might wish to study (say) the impact of fabrication technologies, or 3D display devices, on education; but the single-intervention approach would limit the broad scope of this study to something far less meaningful, such as comparing a program presented on a 3D screen to a similar program on a traditional screen. In short, then, the constraints of "evidence-based" research place counterproductive restraints on educational design, limiting our thinking to specific, artificially isolated technological changes and not to larger systemic or cultural innovation.

Intellectual Motivation. As noted in the previous paragraphs, the disciplinary center of gravity of the cognitive approach tends toward those subjects that are representative of classroom instruction. Thus, one will tend not to see educational research that focuses on (e.g.) hobbies, personal interests, or subject matter that the school system might view as exotic or unorthodox. Likewise, there is little encouragement for technological design that might impact learning in a preferentially non-school context.
In fact, the disciplinary limitations of the current research culture are even somewhat more severe. It's fair to say that—within the bounds of the classroom—there is an emphasis on subject matter perceived as "rational", or at least utilitarian. Broadly speaking, the most prominent candidates for study are reading comprehension, mathematics, and the natural sciences. These subjects are also the foci of technological innovations for educational research. It is less typical to see technological design or research aimed at (e.g.) music appreciation, color sense, creative writing, or performance.

It is interesting to step back a bit and speculate on why, precisely, the disciplinary focus should be as relatively narrow as it is. In part, one might argue that the underrepresented disciplines are precisely those in which affective, aesthetic elements are most prominent—and these elements are least familiar within the cognitive science tradition. While some cognitive scientists have indeed advanced fascinating ideas about the psychology of aesthetics and the arts [Solso 1994, Ramachandran 2004 ch. 3] these ideas have been far less straightforward to implement in computational form than their counterparts in the realm of (e.g.) mathematical problem solving or vocabulary retrieval.

At the same time, it is worth noting that, arguably, there really is a strong affective and aesthetic component to even the "allowed" subjects of mathematics, engineering, and the natural sciences. Often, biographies of scientists and mathematicians place these elements into strong relief. Still, these are aspects of the subjects that tend to be underexplored in learning sciences research: it is far more typical to ask (say) why a student might misunderstand Newtonian mechanics than to ask why a student might (or might not) be drawn to study physics.

We will return to these themes (of affect and aesthetics) shortly; for the present, however, we might focus on yet another aspect of the cognitive approach that impacts choice of subject matter. This is the almost relentlessly utilitarian portrait of education and learning that appears to motivate much of the research community in its decisions on what to study. That is, there is a general (if unstated) syllogism at work that (a) the purpose of education is to acquire a job, (b) there are relatively more jobs to be had in technical fields, and therefore (c) the most important subjects for research and study are technical subjects. By the same reasoning, subjects that offer few prospects for employment (or monetary reward), such as classics or philosophy, are rarely the subject of technological design or cognitive research.

It is an open question whether the utilitarian view of education implicit in the research choices of the learning sciences community is in fact shared by youngsters. There are reports in the popular press of continuing problems with academic retention among students in technical fields [NY Times, 2011]; at the same time, children and teens spend large amounts of time in activities (e.g., sports) for which there is little prospect of gainful employment. Children persist in doing what they like; while the stock images promoted by the educational community that purport to motivate an interest in scientific study (e.g., the need to "acquire skills for the twenty-first century", or to "compete with China") seem to have little or no resonance with the students.

Overall, as noted in a recent National Science Board report [2010], "[f]or at least the past two decades, about one-third of all freshmen planned to study science and engineering", or in other words, the per capita level of college student interest in technical fields has remained approximately unchanged. Thus, measured in indicators of student interest, the result of a decade of work since How People Learn has been a disappointment. As a result, it has become something of a commonplace to say that there is a need for more attention to "motivation" within the cognitive science community, particularly with regard to education. Indeed, the authors of How People Learn anticipated as much:

> Although cognitive psychologists have long posited a relationship between learning and motivation, they have paid little attention to the latter, despite its vital interest to teachers. Research has been done on motivation, but there is no commonly accepted unifying theory, nor a systematic application of what is known to educational practice. [NRC, 2000, p. 280]

In point of fact, there is much more missing in the cognitive approach than an attention to motivation alone; "motivation" is rather a thin term for the myopia that is at work here. More generally, there is a lack of attention to the element of biography, of personal narrative, that underlies young people's choice of activities and commitments. Because the cognitive approach emphasizes a purely rational or utilitarian view of education, it exhibits a concomitant de-emphasis on the individual or idiosyncratic nature of intellectual development. Even the favored research scenario of the learning sciences community—implementing some innovation within a classroom (or better yet, a school district) and studying the average, large-scale impact of that innovation—ignores, by its very nature, the sort of innovation that would have an intense but highly personal impact on the occasional student's thinking. The idea that a student might have a passionate, obsessive, aesthetically based, or highly individual pattern of interests is not addressed.

To sum up the argument to this point: the research culture of the learning sciences community, based as it is in the disciplinary tradition of cognitive science, exhibits important blind spots. Some of these blind spots are disciplinary—subjects (such as the arts) that are relatively underrepresented both in the research literature and in
technological design. Some of these blind spots are structural—an overemphasis on classroom settings, formal instruction, and short-term learning. Some of these blind spots are philosophical—a view of education as exclusively utilitarian, a lack of attention to personal or idiosyncratic factors in intellectual growth, and an overreliance on computational models.

Collectively, these blind spots have serious consequences for the designer interested in creating new technologies for education. Sometimes, it is the subject matter that is problematic: designing a computational system to help students learn (e.g.) choreography, or pottery, or costuming would be seen as an offbeat (and perhaps frivolous) choice of disciplinary focus, even if creating such a system could raise fascinating issues for the designer and have tremendous value for the eventual student. Sometimes the structural bias toward the classroom is problematic: designing novel artifacts to help youngsters tend to their backyard, or to enjoy bird-watching in their neighborhood, or to add programmable computational elements to their own clothing and home furnishings, would be seen as somehow less than fully "educational". Sometimes it is the philosophy that is problematic: designing (say) a novel musical instrument, or science kit, or mathematical puzzle that would capture the imagination of a small number of students would be seen as "low-impact", and hence a waste of time.

The limitations of the current research culture have, in this fashion, collectively hobbed the imaginations of the designers of educational technology. In the following section, we discuss a variety of more productive educational themes, based in anthropology, that could reinvigorate technological design for children.

**Children's Anthropology and Technological Design**

The previous section has sketched a problematic—even depressing—state of affairs in educational technology research. The current research culture is limited in subject matter, in its vision of the setting and timeframe of intellectual development, in its inattention to personal narrative, and in its utilitarian view of education in general. Where, then, can educational designers turn for an alternative theoretical foundation for research?

A source of some hope for the field can, we argue, be found in the burgeoning field of children's anthropology. Sources such as [Opie & Opie, 1959; Csikszentmihalyi et al. 1993; Lancy, 2008; Lancy et al., 2010] are rich in thoughtful description of the ways in which children grow, develop (or fail to develop) intellectual interests, and arrive (for better or worse) at an understanding of their own biography. The themes and issues raised in this field of research offer a fresh lens through which to approach technological design for children.

What follows in this section is an outline of five prominent themes in children's anthropology, and suggestions for how these themes could inform novel design projects. In the final section, we will expand on several of the brief suggestions introduced here, and sketch several potential directions for design informed by anthropology.

**Friendship and Peer Culture.** A recurring theme in the anthropological literature on children is the role of friends (and peers more generally) on development [Corsaro, 2003; Milner, 2004; Harris, 1998]. Children's tastes and language are—as has been well-documented—strongly influenced by their peers. Perhaps more important for our purposes, there seems to be a relation between the role of peer culture and the question of "intellectual motivation" discussed earlier: for instance, one of the memorable findings of Coleman's [1961] famous mid-century study of high school students was that relatively few students actually admired academic success among their peers. There is thus a strong need to design educational technology that not only instructs students, but that in some sense is answerable to the question of creating a supportive peer culture. There might be stronger attempts, for instance, to build online social networks among students based not on a loose definition of "friendship", but supporting shared intellectual interests or construction projects. Likewise, one might design educational technology whose effects include not only intellectual advancement but increased popularity: for example, one might argue that computational kits for designing programmable clothing, or for creating innovative public artwork, would have much greater motivational force for students than (e.g.) programs to help raise test scores.

**Economies.** It should come as no surprise to parents and teachers that an important element of children's culture is the presence of various informal "economies" based on (among other objects) baseball or character cards, model cars, doll clothing and accessories, "virtual" (game-related) goods, and the like. Children collect, trade, and display these objects in numerous forms, and—apparently since the late medieval period if not earlier [Orme 2001, p. 177]—these objects play a recurring role in knitting together the friendship and peer cultures mentioned earlier. From the standpoint of educational technology design, an attention to children's economies would likely lead to (e.g.) the design of "collectibles" that attempt to push the envelope of challenging content. One might imagine (for example) "mathematical collectibles", or perhaps small computationally-enriched pieces that, when combined together, can produce larger constructions. (For a survey of still-early ideas along these lines, see [Schweikardt & Gross, 2007].)
Holidays and rituals. As noted in [Opie & Opie, 1959], the yearly cycle of holidays and rituals plays an important role in children's lives; many holidays (Halloween, April Fool's Day, Christmas) have especially strong associations with children's activities, and birthday parties are likewise important events. A reasonable prospect for educational technology might be to exploit the importance of these events through the design of personalized or creative activities: children might (e.g.) design high-tech costumes for Halloween, magical illusions for April Fool's, or aesthetically appealing packages and wrapping for Christmas presents. Another possibility for educational design would be to create technologically-enriched construction activities, puzzles, or games specifically geared toward events such as birthday parties.

Role models. In biographies of scientists and mathematicians, the accounts of early interest often (perhaps surprisingly often) include the presence of an inspirational role model—a teacher, relative, or historical figure. Just to take one example (many more could be mentioned): the classic book *Microbe Hunters* [De Kruif 1926], with its capsule biographies of intellectually adventurous scientists, appears to have strongly influenced a generation of twentieth-century biologists. (See, for instance, [Hargittai 2011, p. 53].) Technological design for education could attempt to play upon the power of role models in a variety of ways: one might (e.g.) design laboratory spaces intended to reproduce settings, or re-enact events, associated with famous historical figures; or one might create a series of ongoing public scientific projects or experiments whose explicit aim is to highlight the narrative, biographical dimension of science education, showing the scientist at work over time.

Neighborhoods and Hangouts. The settings in which young people live and congregate constitute yet another important theme in children's anthropology. Historically, it is not uncommon for older children and teenagers to find places (“hangouts”) in which to meet; and these places in turn take on the character of the local youth culture (for good or ill). More recently, as Mintz [2004, p. 347] has documented, children spend more time within their homes (and within their rooms), perhaps attenuating the role of the neighborhood hangout; though in other cultures, teenagers still find their way to the local mall. An educational designer might, in response to these factors, attempt to create settings that have perhaps more challenge or possibility than a shopping mall (maybe incorporating some of the features of interactive science museums); or we might design interesting activities that can be incorporated within the settings where young people tend to congregate.

There are still numerous other anthropological themes that could be included in a list of the sort given here. We might, for example, inquire about the relationships that children have with special objects in their lives (souvenirs, hand-constructed items, sentimental gifts), and use that as a basis for designing novel types of educational artifacts. Or we might note that for many children (and older students), a great deal of productive time is conducted on their own, without the company of friends or peers [Csikszentmihalyi et al. 1993, p. 90; Arum & Roksa 2011, p. 100]; so it might be useful to design technologies that can, in some fashion, alleviate the burdens of loneliness while still permitting children to work in solitude. Or we might study the design and decoration of children's rooms, with an eye toward creating display artifacts (perhaps computationally-enhanced) that offer intellectual challenge. Or we might study the patterns of children's intellectual passions and obsessions, and attempt to design educational technology to fit or exploit those patterns.

The following section will outline a couple of potential projects based on themes of this sort. Before moving on, however, it is worth returning to the opening paragraphs of this paper; and it is worth comparing the sorts of design projects encouraged by the “key findings” of *How People Learn* with the sorts of design projects sketched here. There is nothing intrinsically wrong with (e.g.) identifying students' misconceptions, building knowledge structures, and promoting metacognitive skills; but these are peripheral issues when the surrounding culture of children's lives (counterproductive friendships or peer pressure, anti-intellectual hangouts, absence of role models) mediate against intellectual growth. Cognitive computational models are impoverished representations of children's minds and lives, and impoverished bases for technological innovation. As designers, the themes of anthropology collectively tell us much more about how and where to direct our energies in technological research and creation.

Moving Toward the Anthropological Stance: a Sampler of Potential Projects

In this final section, we describe several themes for larger research projects, based upon the anthropological ideas introduced in the previous pages. The suggestions of this section are only a very small sampling of the multitude of projects that could be undertaken; the reason for presenting them here is not that these are the best possible project ideas (a wildly optimistic claim), but rather that they are directly responsive to major issues raised in the literature of children's anthropology.
Project theme 1. Incorporating computational elements into children's performance. There are numerous opportunities within children's culture for various types of public performance. Students take part in sporting events; they take the stage in talent shows, magic shows, plays, glee clubs, and public performances; they participate in events that (at times) occur outside the boundary of the school, such as slam poetry competitions. In all these events, there are elements of costume, choreography, props, sets, and so forth. One potential project, then, would be to incorporate novel types of technologies and design activities into these performance settings. One might employ computationally-enhanced textiles [cf. Buechley & Eisenberg, 2008] to create costumes, sports uniforms, and theatrical backdrops; one might use computer-generated lighting effects in stage performances; one might employ novel musical instruments or sound effects for glee clubs or poetry competitions; one might design novel optical illusions or trick apparatus for magic performances. In summary, then, there are ways of blending ideas from programming, the physical and natural sciences, engineering, and computer-generated arts into the types of events that matter to many students. It should perhaps be pointed out that these types of activities are associated with creative peer communities among students; they are the places where (often) close and lifelong friendships are formed. In this sense, incorporating novel technology into these activities is a potentially powerful way of placing creative learning opportunities within contexts where peer pressure will not run counter to academic achievement.

Project theme 2. Public displays and activities. The previous project idea focused primarily on settings for established traditions of youngster's performances (sports, glee clubs, etc.). There are still other modes of public performance that might serve as excellent venues for novel designs in educational technology. For example, it might be possible to create large outdoor surfaces suitable for projected displays, and to permit youngsters to employ various types of projectors (ranging from large-scale to nanoprojectors) to create massive animated or graphical effects in public spaces. Still other types of group public displays—ranging from flash mobs to political protests to Christmas caroling—might allow for interesting technological enhancement. In some cases, public displays are associated with the individual home: one might imagine creative child-accessible technological enhancements for holiday decorations such as Halloween or Christmas lights, or one might create novel techniques for presenting interesting scientific ideas (rather like a "home scientific museum") in a local front yard. The larger idea here is to rethink the possibility of public settings for educational purposes.

Project theme 3. Children's rooms as objects of design. Thus far, we have focused our discussion on public events—performances and outdoor settings. As mentioned earlier [cf. Mintz 2004] present-day children spend much of their time alone at home, in their rooms. One potential response to this demographic shift would be to create technological activities that are geared toward beautifying, personalizing, or otherwise increasing the intellectual interest and affective poignancy of children's rooms. Electronic textiles might create interesting effects on curtains or wallpaper; long-term computational simulations could be programmed to run over a period of weeks or months, projected on the walls or ceiling of the room; computationally-controlled mobiles, wall hangings, and kinetic artwork could be designed with novel fabrication and design tools; children might be able to personalize or interact in interesting ways with nightlights, a home terrarium, or displays of collectibles. Here, the overarching theme is to design technology that speaks in personalized, perhaps private, ways to children's intellectual passions and obsessions, and that allows them to recreate their physical environment to reflect their own interests and personality back to them.

These types of projects are suggestive of the directions—anthropological directions—in which the design of educational technology needs to turn. Cognitive science, on its own and unaided by the anthropological perspective, has taken us in the wrong direction for too long. The goal of education should be to fashion a living biography, not an internal mechanism.

References
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