Constructionism: Changes in Technology, Changes in Purpose

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1. Introduction: A Crisis of Purpose; and Intellectual Fulfillment as a Subversive Goal

Educational technology–like the field of education in general, and many other global institutions–seems to be in a state of crisis, or at least a state of highly volatile change. The rapid advent of new systems and devices–social networks, cloud computing, fabrication tools, the Arduino and its cousins in the realm of embedded computing, just to name a few–offers tremendous creative opportunities to our field, but at the same time leaves us, collectively, with a painful reassessment of purpose. What do we want educational technology to look like; or maybe, more importantly, what do we want learning, childhood, and adult life to look like in this strange and disturbing political, cultural, and even meteorological era that we appear to be embarked upon?

There are certain stock images and phrases that one hears repeatedly in the field of education–at professional conferences, in political speeches, and in position papers–that are doing us no good in this regard. These include the notions of "invisible technology", "replacing the sage-on-the-stage with the guide-on-the-side", the "wired classroom", and numerous others that, whatever their merits in the abstract, have over time become so unquestioned, so reflexive, as to stunt our collective imaginations. Perhaps the most prominent–and problematic–of these stock notions is reflected in the phrase "skills for the 21st century", or words to that effect. Repeatedly, we are told that "we need to teach children the skills that they're going to need for the 21st century," or "kids need a 21st century education for 21st century skills", or we're asked "where are children going to get those 21st century skills that they need?" This phrasing, with its underlying grim connotations of relentless global competition and mass poverty (in the absence of those much-needed skills), is a depressing mainstay in educational technology rhetoric.

The goal of this (somewhat informal and polemical) paper is to offer several still-nascent reflections on the crisis of purpose in educational technology, and to suggest a variety of themes that could prove a salutary counterweight against these unexamined reigning images that blinker our field. There is really a double meaning here to the words "crisis of purpose", since the words apply to the professional field itself–the researchers, designers, and educators who represent the field of educational technology–and to the children whose lives are continually shaped and affected by the technology with which they grow and interact. We need new purpose as educators and designers; and to discover that purpose, we need to re-imagine the purposes that children might have for themselves.

To pursue this theme for a moment, let's return to the last of those phrases mentioned above. There is in fact a very good argument to be made that children don't really "need skills for the 21st century". Indeed, that phrase conjures memories of Aesop's fable of the grasshopper and the ant: in this case, the child's (ant-like) role is to fill up his or her cognitive storehouse of "skills" during the summer of youth in order to unpack those skills during the coming 21st-century winter

of adulthood. It's an unhappy picture, and there is no particular reason that a child should want to buy into it, even if he or she understands it. A much happier starting point–rather than speaking of a repertoire of skills–is to say that children need something approximating a purpose of their own: a project, a goal, a narrative that offers the possibility of fulfillment. Children don't need skills so much as they need (as do we all) a reason to get up in the morning, and the morning after that. A person equipped with such a purpose will, as people tend to do, acquire the various skills that they need to achieve it. A person without such a purpose may garner dozens and dozens of skills, and spend long months and years in joylessly employing them.

What do these reflections suggest for those of us interested in designing technological artifacts for children? First, and clearly, they suggest that we should not think of our primary role as "skill trainers". Certainly, there are useful technological artifacts that (e.g.) serve as tutors for various skills–for solving physics problems, or rearranging equations in algebra, or recognizing animal species–but such artifacts are inevitably limited, and play at best an occasional supportive role in the much more challenging, important, and ill-defined task of providing children with internally-understood biographies. To approach that task, our goal as designers of technology can be better described as finding *activities* for children: dignified, creative, content-rich things to do. We should think of a technological environment in the expansive sense of providing potential storylines for children to grow with. We should ask questions like "what sort of technological artifacts and environment might provide meaning to a life in mathematics (or music, or chemistry, or any other field)?" Then we should do our best to design objects, tools, settings, and social structures that provide that kind of meaning.

In attempting this sort of design, it might be well for us to admit that intellectual fulfillment is something of a subversive goal in our much-anticipated 21st century. After all, the notion of "skill training" is usually accompanied by an implicit assumption that the intent of education is to pad one's resume and by that means to find a position. This is a utilitarian view of education, and it has its advantages: it's hard to argue in contrast that the purpose of education should be to make people unemployable. At the same time, there is an undercurrent of anomie, of drift, about the utilitarian view: we want education to make people useful of course, but useful to whom, and to what end? If the goal of education is simply to find a job, then the ultimate purposes of one's intellectual life are largely ceded to one's prospective employers. It is in this sense that we need, as designers, to acknowledge, even accentuate, the subversive elements of true education. Educational technology, at its best, can be a spawning ground for the idiosyncratic, the weird, the unexpected, and the hilariously useless life project.

The remainder of this paper explores the ways in which the altered landscape of children's technology may enable us, as designers, to rethink our own and children's purposes in education. The goal of this reappraisal is to create life stories that are not merely functional, but fascinating–that is, to view education as a means of cultivating idiosyncrasy, of providing the means for achieving creative joy and frustration.

2. The Expanding Boundaries of Children's Technology, and What They Imply for Educational Constructionism

One reason that this is an opportune moment for standing back and rethinking the enterprise of educational technology is that the very notions of "technology" and "education" have vastly expanded beyond their confines of a generation ago. Up until the previous decade, anyone discussing "educational technology" was almost automatically discussing "classroom computing": that is, "education" was reflexively linked to school settings, and "technology" to the

computer (particularly, the desktop computer). Naturally, there were important exceptions to this broad-brush statement–such as work in non-classroom settings like children's museums, and work with non-desktop devices like robotics kits or handheld devices. Still, at the risk of only a mild degree of caricature, the term "educational technology" has conjured a standard image of children in school settings, using computers.

Within this tradition of educational technology, the constructionist subculture has always had a close association with the Logo language and with children's programming more generally. In this sense, despite its emphasis on children's creativity and independence, and despite its deep interest in experimental and unorthodox models of educational practice, "constructionism" has tended, as a philosophy, to share with the rest of the field a focus on computing as the epitome of technology. That is, most of what might be called "constructionist" research and design has not especially challenged the default notion of "technology" noted in the previous paragraph.

The current explosion of children's technology beyond the boundaries of computing alone now suggests a more expansive definition of "constructionism"–a definition that is in some sense truer to the very idea of "construction" as an appropriate activity for children. It is because technology now facilitates a powerful culture of accessible and interwoven *physical and virtual* construction that children can now create artifacts well beyond those that can fit inside the confines of a desktop computer. Technology is now, collectively, the basis of long-term individual creation: it is the collection of equipment and techniques that permits children (and adults) to cultivate their own personal workshop. Constructionism, therefore, is now the educational philosophy that underlies the growth of a "maker culture" for children, encompassing devices and materials beyond computers alone, and accommodating settings, activities, and peer groups beyond those associated with classrooms.

The key elements of this expanded technological landscape are (a) affordable fabrication devices such as 3D printers, laser cutters, desktop milling devices, computer-controlled sewing machines, (b) accessible artifacts for embedded computing such as the Arduino and LilyPad (along with numerous related devices such as low-cost sensors and actuators), (c) a rich collection of novel construction materials, prominently including conductive threads, paints, and adhesives whose use dovetails with electronic elements, and (d) a social and informational infrastructure provided by the Web that enables users of all ages to learn construction techniques and to share, exchange, and display their ideas in a worldwide community. This list could, naturally, be expanded; but these elements are foundational in a technological shift that enables young people to "construct" such items as home scientific equipment, sensor-enabled Halloween costumes, sophisticated kinetic sculptures, personalized musical instruments, and an endless list of other possibilities.

The technological landscape outlined in the previous paragraph is not only incomplete, but it is rapidly evolving: for example, the state of personal (or child-friendly) 3D fabrication is already much farther developed than it was only two years ago. For the purposes of our own community as educational designers, it is important not only to *acknowledge* but to *drive* this evolution and development–that is, we need to articulate how technology such as 3D printing *should* look in the future if it is to be a useful and expressive medium for children. We need to design novel devices, hardware, materials, software, and social structures that make (e.g.) 3D printing, microprocessors, conductive threads and paints, and so forth meaningful to children's lives and work. The history of home computing in the closing decades of the past century–and its occasionally frustrating evolution from an earlier world of giant mainframes and laboratory minicomputers–suggests that the cultural translation of technology to children's worlds is not automatic. We, as designers, should not simply expect an all-wise technological marketplace to turn its attention to children

and to learning; these are developments that we ourselves need to undertake and spearhead.

In thinking along these lines, we need to bring that central question of children's purpose to the fore. How, for instance, might we design 3D fabrication devices that answer to children's projects–things like designing elements of costumes, or charm bracelets, or model cities, or dioramas? How might we design devices and techniques to introduce children to the types of (often daunting) three-dimensional modeling that accompany fabrication projects? How might we design embedded devices–sensors, actuators, and processors–that "fit well" with a wide variety of children's projects, ranging from giant-sized playground constructions to smaller-scale robotic creations to tiny wearable objects? How might we design safe, creative "smart" or conductive materials that work as flexibly in children's crafts as the long-time "classic" materials such as ribbon, yarn, and beads? How might we create social networks that support values of perseverance, tolerance (but not passive acceptance) of failure in construction, and creative growth? These are the kinds of design tasks appropriate to a focus on finding purpose in an era of "expanded constructionism". Again, rather than worrying about skill-training, the goal here is to create challenging, rewarding, and expressive ways for children to spend their time.

One additional point to make in this context is that, because the "technology" part of "educational technology" has expanded so dramatically, it has driven an increasing reappraisal of the "education" portion of the concept as well. Rather than focus on classrooms as sites of learning, the advent of tangible construction suggests experimentation with "maker spaces", community labs, and home workshops. Portable and handheld devices offer possibilities for educational activities that take place in museums, in city streets, in playgrounds, and in parks; and (the most dramatic of all these changes) the advent of learning communities over the World Wide Web enables educational communities and exchange far beyond (and often very distinct from) those associated with the classroom. In short, we can now envision educational scenarios whose settings and structure are very different from the "classic" picture. Instead of a room, we might begin our imagined scenario with a child in a setting such as a farm, or the roof of an apartment building, or a national park; instead of a school course that plays out over a semester, we might envision certain activities that play out over an hour while others play out over a period of years or decades; instead of a desktop computer, we might envision myriad tiny programmable devices of a wide range of sizes and purposes; instead of a pencil and paper (or typing at a keyboard), we might envision children working (via fabrication tools) with wood, acrylic, conductive ceramics, and numerous other materials. The two terms joined in the phrase "educational technology" move in tandem, advances or experiments in one allowing for related movement in the other.

3. Three Central Tensions for the Future of Children's Technology

The previous sections might justifiably be accused of "technological optimism"–a view that focuses on the best or most exciting features of novel technologies, and imagines (or tries to imagine) the most benign possible future that could emerge from those technologies. Perhaps it is simply human to harness one's hopes for a better future–especially where children are concerned–to changes in technology. At the same time, it is worth noting several prominent "tensions"–dimensions along which debate are likely to be framed–that are likely to be highlighted by the coming era of expanded constructionism. These tensions are in fact not at all new; they reflect ancient, complex, and perhaps ultimately irresolvable polarities that govern children's learning and adult lives. Still, the evolution of educational technologies will likely place these several tensions in a new and starker light.

Tension 1: The private and idiosyncratic versus the public and collaborative

Much of the current rhetoric in educational technology focuses on the (very real) effects and benefits of collaborative work and new social structures for children. Children are able to (e.g.) share and remix programs, display photographs or videos of their constructions on various "maker community" websites, take any of a burgeoning number of online courses, and watch educational videos. The World Wide Web is at the center of these social and collaborative innovations, and its potential for altering the map of education (e.g., for providing viable alternatives to the traditional classroom social structure) are quite real.

At the same time, many of the innovations discussed in the context of this paper–3D fabrication, embedded computing, crafting and construction with novel materials–have a private, solitary dimension to them. Technology is not only about supporting groups of people in collaborative work; it is also about providing the means and time for long-term, patient, solitary work as well. The new breed of technologically-supported workshop, and the new breed of constructionism, needs to steer a careful path between the benefits of company (creating for an audience, learning from friends in a community of builders, asking for advice from experts) and the benefits of solitude (reflection, patience, and the development of an idiosyncratic, personalized vision of one's own construction work). A workshop is, at times, a solitary, quiet place; but even in its quiet moments it is representative of an outside community of practice.

What this means for constructionist education is that, for those children who follow a strange and unscripted path to their own fulfillment–designing their own musical instruments or compositions, creating sculpture in novel materials, adventuring into their own realm of scientific experimentation–there should be the means for giving them time and privacy, and means for providing the occasional dose of social approbation and support. The new technological landscape highlights the polarities of solitary (and sometimes lonely) creation on the one hand, and collaborative (and sometimes therefore too shallow) creation on the other.

Tension 2: Control, order, and mastery, versus wonder, passionate chaos, and lunacy

Those of us who are interested in the general field of science and mathematics education are unfortunately prone to a particular fallacy. We tend to believe that, because we wish to help children find an approach to rational thought, there must be rational means to that end. We believe that there must be a "science of science education", and that children come to reasonable ends via reasonable means.

In fact, experience and numerous biographies show that children do not become interested in mathematics or science for particularly rational or utilitarian reasons (e.g., to "learn skills for the 21st century"). Instead, they come to these fields through the same personalized, idiosyncratic, aesthetically motivated, emotionally overwrought, largely irrational pathways through which people come to other fields such as music and art. A child might wish to learn science to show up a bully among his peers, or to outshine a stellar older brother, or to set a good model for a worshipful younger sister. A child might spend time building apparatus to impress her parents, or delve into the local woodland to get away from her parents. Perhaps most hopefully, a child may develop an interest in science out of an aesthetic calling: staring upward at the night sky to feel that rush of insignificance in the universe, or gazing downward at an anthill to experience both a sense of anxiety and biological comradeship.

Much of current educational rhetoric, as already noted, focuses on images of mastery and control–the acquisition of skills, the development of professional identity, the accretion of factual knowledge. Admittedly these are recurring and often important elements of education, particularly in the sciences and technical fields. At the same time, the new technological landscape enables–or should enable–us as designers to create artifacts and systems that recognize

the individual, the passionate, and the strange side of every successful educational biography. These two themes–the Apollonian side of education (with its emphasis on rational goals and scientific progress) and the Dionysian side (with its emphasis on the passionate, the unexpected, and the personality of the outlier) are both elements of a new era of constructionist design. We can create crystalline, Apollonian programming languages, courseware, and instructional websites; and enable Dionysian projects such as the creation of otherworldly kinetic sculptures, computationally-enriched ventriloquist dummies, humorous musical instruments designed to be played by three people at once, and a myriad other possibilities. Both reason and lunacy are essential elements of educational design and practice.

*Tension 3: The abstract and ethereal versus the messy and physical*

In the early days of educational technology, designers and researchers focused on the desktop computer as the archetypal instrument; and they tended to devote their rhetorical attention to the themes of abstract computation. Thus, we would hear about the ways in which computers promoted new symbolic representations, or complex scientific simulations, or experimental mathematics, or (as the Web came into prominence) of collective minds and virtual communities.

All these elements remain important in the current technological era, and all have an important place in a rethought version of constructionism. Programming languages do indeed give rise to novel symbolic understanding and notations; simulations do enable us to approach scientific phenomena is powerful ways; virtual communities and worlds do exhibit many advantages not found outside the realm of the computer. Again, however, the advent of technologies for physical creation allows us to return to a deep appreciation for, and satisfaction in, the natural and engineered worlds of "real life". There are features of natural environments, physical constructions, and hands-on activities that simply cannot be imitated, replaced, or superseded by the virtual world. Children live in physical rooms, surrounded by their own constructions, decorations, and souvenirs; they trade and collect physical objects, which then become the currency of informal classroom economies; they give and receive physical gifts. The ability to construct with a vast arsenal of novel techniques and materials should now reawaken our interest, as designers and educators, in the integration of and distinctions between the symbolic (abstract, "virtual") and tangible (messy, material-based, "hands-on") realms. We can create programming languages and virtual communities geared toward physical creation; we can imagine construction projects that blend virtual and physical elements in all sorts of unexpected ways; we can control physical objects via symbolic commands, or use handmade physical objects as new types of input devices for computational worlds.

Conclusion

For people interested in education–indeed, for all human beings–there is much to be nervous about in the coming decades. There are profound questions about resources and their availability–water, energy, living space–in the near future; there are predictions (not always implausible) of various types of economic, geopolitical, and climatological catastrophes; there are uncertainties about how technologies will affect (and perhaps disrupt) institutions such as higher education, medicine, and the arts.

In such an uncertain, and nerve-wracking, time, the role of educational designers should be not to serve established power in any form, but to promote optimism. The coming century may indeed be a tough one for us and for our children to get through; but there are sources of joy and intellectual wonder for people to achieve as well. The goal of the constructionist community should be to create examples, artifacts, tools, techniques, and social support structures to give
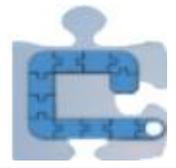
ourselves, and our children, continued sources of personal pleasure and reasons to hope.

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