Can You Tell Me How to Get, How to Get to e-Learning: Development and Complexity

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Though e-learning is primarily aimed at much older students, essentially adults, the cognitive processes become exponentially more complex with age. For the sake of clarity, we will discuss learning as it occurs conspicuously in children. Once understood, we can reapply these principals to college level development.

In the 1960's, television was deemed mutually exclusive to development, and for good reasons. But somehow Sesame Street managed to transcend this impasse, and accomplish an admirable job within an uncooperative medium. It is important to appreciate that the preceding 'educational programming,' despite insufficiencies, should not be seen as a failure in general, but initial attempts necessary to reach the unusually high standards Sesame Street achieved.

An appreciation of core educational theories is crucial for creating classrooms in a software medium. One need not subscribe to these theories

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per se, in order to benefit from their implicit strategies. What one discovers is that digital calculation, the fundamental function of absolutely all computers do, is incapable of non-empirical processes (ie. open-ended problem solving important to education). Nonetheless, Sesame Street's methodical testing paradigm, where media are merely means not ends, by investigating how minds might be addressed in the act of perception/interpretation of that mean, allows disappointing idiosyncrasies inherent to the medium to become useful features available to producers.

1 Introduction

Creating educational web sites can be an interesting challenge. But before we can enjoy the instant gratification of designing a project, we might pause a moment and do some preliminary hard work. A skilled teacher rarely enters a classroom and operates solely by intuition, with more than a parental instinct as a guide, employing informed goals as to what students should learn, and strategies as to how these might be accomplished. Though this instinct is reasonable for parenting a few children from infancy, it is rather flawed for larger numbers of school-age children, particularly in education.

Though e-learning is not usually aimed at younger students, their needs particularly highlight problems we must address. One concern is that college and graduate students can easily amass a 'suggested reading' list, researching topics of interest on-line, and so on without need for formalized direction. Formalization encourages a traditional *dictatorial* model of learning, where the learner must previously have developed the conceptual framework and is filling in that framework with fairly trivial data. In light of these obstacles, we are forced to address what benefit might e-learning hold?

2 Complexity

Technical complexity has long been useful regarding networking processes (Arthurs & Stuck, 1978; Chaitin, 2005; Shannon, 1948). However, we identify at least four distinct types of complexity A) according to a strict mathematical definition, as applied to abstract mathematical systems C) in some concrete aspect of computers, N) in nature, and O) a qualia-like description occurring in human observation. To begin, we are entirely justified in describing a mathematical system as exhibiting complexityA.

2.1 Senses of Complexity

Problems occur as numbers come to be primarily considered symbolic of concrete objects. We might imagine that all things a computer knows – has stored in memory slots, or could know might indeed be listed on a long piece of paper. After all, these slots are concrete objects that do not simply appear and vanish. This idea appears in Alan Turing's (1936) analysis of computation, and is inherent of the "von Neumann architecture." that remains fundamental to computers. A uni-dimensional, linear list such as this, not unlike dominoes which can be recursively rearranged ad *infintum*, is fundamental to computer processing. However, no matter how long this list, no matter how many additional dominoes are added, the system can never possibly qualify as attaining greater complexity.

Because absolutely all functions, interface or computational, are formulated as binary commands (Nisan & Schocken, 2005; Wright, 2012). No matter how complicated these equation may appear to us, a computer only solves each one as a long series of simple, exclusively two-term, *isolated* commands of the form (source memory address - operator - operant - destination memory address. Whether a result resides in memory, a value is explicitly placed at the address by the programmer, or the slot contains a random string of ones and zeros due to corruption, any previous commands are entirely unknown to the processor. Complexity$_C$ is ultimately a mirage. A good example of this is Claude Shannon's belief (based on personal observation and conceptualization) "communication" between machines is analogous to communication between selves (1948), though no more communicative than the gears of a watch inevitably obeying physical laws.

Furthermore, though a computer, or even a network of them, cannot technically attain complexity$_N$, might machine *operators* introduce such an effect? This is a common source of ambiguity, as compexity$_A$ becomes envisioned as complexity$_N$, yielding solely complexity$_O$. A very similar effect occurs with social software. Nonetheless, according to the rules of correct scientific method, man-made systems are invalidated for consideration, by their designers. This is because both the Eliza effect (Weizenbaum, 1966), as well as the perceptual magnet effect (Patel, 2008:80 – 82), encourage the interpretation of more precise organization, when the object with which the human observer is engaged is detected as close enough to *expectations*. The problem lies in the fact that observation is entirely active, not passive, and thus the observer is always a designer, if only of the system as it occurs in the observer's mind. Without strict restriction to exclusive complexity$_A$, whether other forms of complexity occur, complexity$_O$ is all we have access to. The interpretation of complexity$_N$ resides exclusively in the eye of the beholder (Dewey, 1910; Ullén *et al.*, 2010).

2.2 Social Insects

The issue of complexity$_N$ becomes hazier as we consider nervous systems with only a few neurons, as we attempt to ascribe causality and intention to a repertoire of only a few observable behaviors (Roeder, 1963). An conspicuous problem lies in the assumption that complexity$_N$ is relevant to compexity$_A$.

Perhaps more interesting though, is an issue involving the ant colony. The forager ant colony appears particularly well managed, as if comprised of the perfect population of absolutely devoted workers for each task and/or an ideal task manager. However, Deborah Gordon explains (1999, pp. 127 – 130) how it might appear that ants' genes arrived at this 'optimal' solution. This theoretical ideal management is sought in economics, sociology, and particularly computer programming and social software design (firmly based on the principals outlined in von Neumann & Morgenstern, 1944). The key to understanding colony efficiency is that colony activity is merely the amalgam of independent, mechanical choices made by the simple brains of each individual ant, responding to chemical cues to ascertain which of a few task needs another worker. There is no holistic organization. When all tasks have enough workers, the ant simply returns to the nest and shuts down (similarly to hibernation) to conserve calories. The complexity$_N$ required to manage, much less to manage well, cannot reside within any ant speck we might call a brain. We can never know whether natural instances of network behavior does occur, only that we observe outward behavioral patterns that *remind* us of networking. A very common innocuous type of anthropormorphizing is stated below.

> *By functioning in self-organized groups, insect workers are capable of solving complex problems... In some situations unanimity is crucial… collective decision making occurs between two extremes: consensus decision making leads to all animals of a group doing the same thing, whereas combined decision-making means that each individual chooses its own option.* (Güter, 2011, p. 173)

Actually, the workers are incapable of solving complex problems, but are fortunate enough to belong to a group in which the amalgam of individual behaviors serve the needs of that worker well enough. A worker who is intent on the task of foraging, falls short in the task of nest building, but usually suffers no dire consequences since another worker will likely be covering for that job (and insufficiently foraging). Though this hardly proves coordination does not occur, it does show that the presence of *coordination is not something we can assume*.

Emergence, outside of the realm of mathematics, is prone to such mistakes in logic. Machine learning differs from human learning, though it is rather similar to insect learning. However, we need only point out that in short-lived species, learning actually plays a very minor role in the organism's behaviors, where genes predict a species-typical environment well enough (Bjorklund & Pellegrini, 2002; Millikan, 1995; 2000). In a human lifetime that environment, especially given our ability to travel far from where we are born, (un-insect-like) learning becomes more essential.

3 Pedagogies

Behaviorists' *instrumental conditioning* (IC) remains a deep-rooted idea about learning for many. Particularly in computer neural network design, programmers often tacitly assume that because this paradigm renders computer learning feasible, therefore must explain how biological learning occurs as well (Adbi *et al.*, 1999; Sporns, 2011). Of course, when the logic is spelled out, the doctrine hardly makes sense. Intrinsic to IC is a tacit assumption that an ideal condition, not unlike the "God's eye view" (Edelman, 2004, p. 140), is a viable possibility. Thus if a child performs unpredictably relative to a child who performs *as expected*, the former child is assumed to be deficient in some way the latter child developed correctly. This view is most salient, possibly inescapable, in computer neural networks approach to learning as a universally consistent (as are the principals of computer operation).

> *Neural networks and other cellular and chemical mass action systems are often of this form [he cites only 3 references to his own work here.] The systems also suggest new models of stable economic markets (M. W. Hirsch, personal communication).* (Grossberg, 1979, p. 382)

Grossberg's four references are telling here. His interpretation of his world (generally a world of mathematics in higher academia) is generalized to other now stereotypical domains, such as biology (Enquist & Ghirlanda, 2005; Henkel & Kok, 2005) and economics (von Neumann & Morgenstern, 1944). Of course, as discussed previously, subjective recognition of similar *groupings*, is not at all evidence of any physical, causal relationship.

Meanwhile, education theorists have become dissatisfied with the IC model, primarily for moral reasons, rather than intellectual ones. One alternative is *Progressivism*, which assumes a child learns impulsively, by some unidentified mechanism (Montessori, 1967). With the most humane intentions, often these alternatives are still practiced as only trivial variations of IC: rewarding chosen behaviors. John Dewey is often credited as the father of progressive education, though rarely with appreciation for his technical psychological insights as to why teach one way and not another..

Dewey's reasoning is of utmost importance to us here. For instance, we do learn from dictatorial methods – such as reading this sentence. But according to Dewey, *novel* ideas, for the student, are assimilated by participation in games or mental puzzles. In the case of dictation, some students will learn, but only do so by inventing private games for themselves. Many students will not recognize how the lesson might be transformed this way and inevitably come to associate the subject with discomfort (Dewey, 1910; see also Deacon, 1997, pp. 294 – 296 for modern neuro-imaging evidence of this).

3.1 Constructivism

Constructivism solves many problems from philiophical ones to pedagogical practices. The term is often invoked (for instance in Atan, Samsuden & Idrus, 2003; Enobun, 2010; Morphew, 2000) without consideration for Jean Piaget, easily one of the most influential theorist in the study of development, in human children or nonhumans, particularly his *Genetic Epistemology* (1971). Though he was extremely prolific, two of Piaget's books on child development are of great importance (1929; 1962) to us here. Constructivism, the means by which concepts are constructed in a boot strapping way within the mind and not assimilated from *outside* (as in a Platonist scheme, see Changeux & Connes, 1995 for this debate), has evolved to become *neuroconstructivism* (Karmiloff-Smith, 2009). Confusing matters, primarily on the web, this term is used more similarly to *social learning* according to another icon of education theory, Lev Vygotsky (1978; 1986; see also Cosmides & Tooby, 2013). Vygotsky posits that all social interactions are means of learning (and not that *all* learning occurs socially). Though scaffolding is recognized outside of constructivism, it takes on special relevance when considering how the mind arrives at new concepts by means of directed mental conflicts. Though progressivism is helpful in encouraging students to learn in a comfortable environment, the interactive cognitive process is more complex.

3.2 Scaffolding

Scaffolding is an advanced form of feedback, where *cybernetics* (more appropriate to computers' limitations in transmission), while hardly the lowest, is an intermediate form. Cybernetics, as postulated by Norbert Weiner (1948; 1950), requires that the exchange remain within highly predictable parameters for both parties, as in signal-use, such as alarm cries (Cheney, 1984), bird songs, and bee dances (von Frisch, 1967) of nonhuman animals. Scaffolding (Gould, 2005) is akin to language-use, as found *exclusively* in humans (Fitch, 2012; Shettleworth, 1998).

As with the nature-nurture debate that has been replaced with a consideration for the interplay of ontology and phylogeny (Langer, 1998; Sirois & Karmiloff-Smith, 2009), the distinction between top-down and bottoms-up methodologies fades from pedagogy with *scaffolding*, particularly taking into account Howard Gardner's *multiple intelligences* (1983). He describes, in psychological terms, how individual brains exhibit differing strengths and weaknesses per domain. Though details of this theory have been debated, an implication for us remains that these "intelligences" are personalized solutions to environmental tasks, rather than apprehensions of reality (for a discussion in ethological terms, see Shettleworth, 1998). It is crucial to e-learning that a student may provide correct answers on tests, but is often unable to generalize problems sufficiently outside of the classroom, or cannot do so separately from an authority figure's approval and encouragement (Fosnot & Dolk, 2005; Pogrow, 2004; Sfard, 2008).

While redefining a word like "addition" would be counterproductive to the sciences, it still could be justified as expressive in other domains. Despite his unorthodox (bordering on lyrical) uses of well-established, strictly defined, technical terms, including "complexity," social theorist Edward Morin (2008) argues, from a personal moral stance that as "cybernetic" interactions become unpredictable due to increasing *complicated-ness*, the underlying concepts can too often be reduced to generalities in reification. In light of our discussion, his qualification of unpredictability implies only identification of complexityO, a subjective interpretation of an otherwise incomprehensible system. While Morin's argument might well be applicable to *knowing/recalling*, such a generalization reflex in humans is ultimately integral to perception/comprehension, and thus *learning* (Edelman, 2004; Gregory, 1966; see also ideas in Calvin, 1999; Minsky, 2006 regarding the role of competing messages resulting in unified outward behavior). Given Gardner's insight, we can view the simultaneous need for and avoidance of generalization as a paradox or a fulcrum on which teachers must balance personal cognitive limits with appreciation for the propensities of the individual students. This has particular relevance for on-screen interface designers.

4 The Need for Testing

Because we suspect complexity$_N$ occurs in a system, can only observe complexity$_O$, and cannot 'un-observe' it consistently, that system must be tested with others (ideally the target audience) to determine that system's effect (ie. to differentiate between individuals speaking sequentially versus a conversation). Our species-typical view is critical to authorship but insufficient in this respect (Gregory, 1966; Howes, 2002). It would be impossible for humans to perceive the independent activity of an ant colony to be somehow holistic, subject to a gestalt effect on a conceptual level, and still call it a "colony."

4.1 Media-specific Testing

Unrestricted personalization of the immediate environment (such as graffiti) can be a positive aspect for learning (unlike being instructed to submit an icon to stand for the student). This hardly implies that very different positive aspects do not exist in online classroom settings. But what exactly are they? Without rigorous experimental results as guidelines, even social software's role in learning, where interactions are ultimately performed between humans, the machines functioning almost exclusively as media, is suspect (Wright, 2007).

Gaming enthusiasts might cite increased hand-eye coordination skills as one developmental benefit of software use (Donovan, 2010; Wagner, 2000). There is an overwhelming supply of supposition in favor of gaming, but rare conclusive testing. Rather, the scant methodical research indicates that these and other popular educational strategies, such as playing violin or dance instruction at an early age, are not actually generalizable skills (Grafton & Cross, 2008; Sfard, 2008). It is fairly clear that this training serves only to (temporarily) hasten – not improve – development in the given domain by atypically redirecting cognitive efforts. This may even retard the development of other cognitive areas that would ordinarily be attended to at that stage (Bjorklund & Pellegrini, 2002:185 – 188). Not to say that gaming is good nor bad, but that we cannot *insist* it is good with ambiguous data.

Another important example of testing in education comes from the ongoing development of The Exploratorium science museum in San Francisco. Much detailed information is available to educators from Exploratorium's press (for example Humphrey & Gutwill, 2005). However, it is less obvious, though not at all incorrect, how the museum might be considered a *medium* resembling the web. Television is very obviously a elementary example of a medium.

4.2 The Distracter

Sesame Street (SS; 1969 – *present*; though we are primarily concerned with the first few years that the show aired; Borgenicht, 1998; Gladwell, 2000, pp. 89 – 101; Morrow, 2006) began with the problem that *television cannot teach!* This was not an unwarranted argument, but one we need not go into here. For decades, 'educational television' had existed, albeit the vast majority of shows were flawed by nearly all accounts. Nonetheless, even before it was aired, SS was highly praised as a teaching tool. The show accomplished this remarkable feat by setting aside the above assumption about deficiency, thinking in terms of what the audience member perceives, rather than what the medium does. Subsequent research by and testing *with actual children* guided (and continues to guide) SS's producers at Children's Television Workshop's (CTW) choices about how 'lessons' might best be presented.

Though we need not attend to specific methods used, the model that SS initiated, serves our purposes ideally for e-learning. Many sub-tests proved helpful to CTW, for instance children adamantly did not want "Big Bird" to attain another name, however no final evidence was found regarding their ultimate goal, to determine how well SS prepared pre-school children for the social/institutional world ahead of them. Nonetheless, reapplication of their methods remains essential to e-learning.

An interesting testing device their researchers came up with was the "distracter" (Morrow, 2006, p. 79 – 82). As the name implies, while SS was shown to children in focus groups, a second monitor showed other random scenes and images. The testers recorded the uninterrupted length of time children watched SS, to determine which skits and parts of skits, held attention best. Though there are surely differences in distractions due to the target age, e-learning does compete for attention, as SS did. The fact that students are free to search elsewhere on the web for information is significant. Though counting hits on the web pages is easy enough, we have no idea if the student simply navigated to the page, felt overwhelmed by some aspect of it, and left the room. This is precisely the purpose of a human teacher, to respond to those impasses, impasses that are fundamentally impossible for a computer to predict or recognize. This is but one crucial problem we must face.

Conclusion

Not that there has been no testing regarding e-learning, but that scientific investigations are dwarfed by numerous speculative accounts, which are further dwarfed by premature implementations. Even in cases where educated educators direct the design of web sites for children, the technical work being far removed from their hands, the sites tend to lose their theoretical educational influence. Testing concrete results becomes all the more crucial. Though complexity$_A$ is entirely valid, complexity$_O$ is essential for perception, and perception essential to adaptation and learning. Furthermore, complexity$_N$ may occur (whereas complexity$_C$ strictly cannot), but it is this compulsive projection of complexity$_O$ that defies intuition and the "in the lab" speculation, which makes a culture of methodical experimentation so crucial for e-learning.

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