# Educational Technology Points of Inflection

## Michael D. Bush

## Getting to Where We Are and Need to Be with Educational Technology

For the past 37 years I have thought a lot about the impact that technology can have on how learners learn. That reflection notwithstanding, I was still unprepared for what I saw in an article on the front page of the *International Herald Tribune* this past summer. I will return to that in a moment, but a little background will help explain my reaction to what I read.

### Background

My reflection on technology in education began in 1975 when I interviewed as a young Air Force officer to teach at the US Air Force Academy (USAFA) in Colorado Springs. At the conclusion of the interview, the Head of the Department of Foreign Languages said that he was looking forward to seeing me and my family there the next year. His comment surprised me a bit, given that I had not yet accepted an offer. I was finishing an MBA in the missile launch officer program, which was the main reason for which I had volunteered for that assignment. The degree qualified me for teaching duty at the Academy, if I were to decide to continue a career in the Air Force, but my plan to that point had centered on the idea that going into industry with my MBA would support my family better than a career in the Air Force. Perhaps seeing a little puzzlement in my face at his comment, the Department Head and my future boss then said, "Oh, by the way, we are looking at using the computer in language teaching."

It is hard to imagine a single event having a greater impact on a person's future than a simple phrase such as that. The colonel knew of my interest in computers that had found expression during my coursework in the "quantitative methods" option, which was new in our MBA program administered by the University of Missouri. A portion of my work in my Air Force job involved using the computer to try to solve what was a tough scheduling problem for missile combat crews, a project that I had begun on my own time in addition to my missile launch office duties and academic studies.

Although my interest in computer technology was common knowledge after my arrival at USAFA, no one was more surprised than I was when the Department Head called me in a year and half into that assignment and offered me the opportunity to pursue a PhD and to specifically make computers part of my studies in Foreign Language Education. Educational technology as a field of study was non-existent at Ohio State when I entered there in 1978, so I did a third of my coursework in computer science.

The interest that I pursued at Ohio State in using the computer for solving interesting problems had begun seven years before, during work I did with one of my professors in my undergraduate program in Political Science at Brigham Young University (BYU). His class discussion on voting blocs in the United Nations General Assembly prompted me to dust off the programming book I had used a couple of years earlier and write a program to do the analysis, which resulted in a job as his undergraduate research assistant.

### The Computer as a Personal Tool

This professor taught me through that work that the computer could serve as a personal tool for accomplishing useful tasks. Such a lesson was less than obvious at the time, given that the computers of the day were huge behemoths located inside air-conditioned, glassed-in enclosures. The computer where the UN programs ran was across campus from where I had my classes, but the first one that ran the crew scheduling programs was located across the country. In the latter case, I connected using a terminal connected to a telephone line via an acoustic modem and used that approach until we finally got our very own card reader and line printer in the building where our MBA classes were held. I can still hear in my mind that printer thumping away on each line of output that had been generated by a computer located 90 miles away.

In each of those two cases the rooms where those computers were located were filled with a variety of desk-sized devices, units like the control panel with its flashing, multi-colored lights, others with spinning reels of tape, and still others that accepted stacks of magnetic platters for random access storage. Not to be forgotten were the noisy line printers that spit out endless piles of huge sheets of paper filled with lines of 132 characters each. Our programs and data were punched on cards, decks of which we submitted at a window where we could later return to collect a printout of our results. Going back a couple of hours after dropping off the cards, I would often discover that I had no results because one line of the program was missing what seemed like a very insignificant comma. As an aside, I remember well one of my MBA professors wondering why, if the computer could figure out that a comma was missing, why could it not just insert it?

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## The Effects of Moore's Law

The vision behind that professor's comment is reflected in the way programming environments work today. They are structured to help programmers be more productive by offering suggestions of the options that are available as the development of a program proceeds. Even more remarkable, however, is the fact that a typical iPhone executes about 2,000 times more instructions per second and accesses about 2,000 times more memory than the huge computers of my past. These increases in performance are nothing short of amazing, but they illustrate the effects of Moore's Law, which says that the number of logic units (semiconductor elements or transistors) on integrated circuits doubles about every 18 months or two years. The initial prediction of that exponential growth was made by Intel's Gordon Moore in 1965 and has held true ever since. Even more remarkable, however, is the vision of my undergraduate professor who convinced me that a computer could be a tool of personal convenience, a vision inspired quite surprisingly by huge computers controlled by a select few but one that spans the technological advances of the past 40 years.

During this time the world has seen an incredible transition from the computers in the glass-enclosed rooms that ran the programs to analyze voting in the UN General Assembly, generate the crew schedules, or control the PLATO terminals the USAFA department head had in mind when he spoke of using the computer for language learning and when he later sent me off for my PhD. Those machines had much less power than one can hold in the palm of the hand, power that has led to the circumstances associated with what I read about in the *International Herald Tribune*.

## The Educational Technology Landscape Today

Here is the front-page headline I read while standing in the baggage-check line at Charles de Gaulle Airport in Paris during our return trip from my wife's hometown in Bordeaux: "Consortium bolsters shift in university education." The writer began that piece, "As part of a seismic shift in online learning that is reshaping higher education, Coursera, a year-old company founded by two Stanford University computer scientists, will announce on Tuesday that a dozen major research universities are joining the venture" (Lewin, 2012).

The article also includes this paragraph:

> "This is the tsunami," said Richard A. DeMillo, the director of the Center for 21st Century Universities at Georgia Tech. "It's all so new that everyone's feeling their way around, but the potential upside for this experiment is so big that it's hard for me to imagine any large research university that wouldn't want to be involved." (Lewin, 2012)

Seismic shift? Tsunami? As descriptive as these terms are intended to be, their impact was overshadowed for me by the matter-of-fact reference in the article to the ouster of the president of the University of Virginia (UVA), one of Coursera's initial consortium members over the debate regarding online instruction. Given the number of years I have been reflecting on the impact of educational technology and the amount of resistance to educational technology that I have witnessed, I was incredulous that a university president could be fired because she was *not moving quickly enough* in the area of technology-based learning. Although the president was reinstated almost immediately, the fact that the people who guide the strategic direction of a major university could be so much in favor of new technology was nothing short of astounding to me.

While that change reflects what is happening in higher education, dramatic changes in secondary education are also on the horizon. Clayton Christensen of the Harvard Business School and his co-authors speak of a prediction that "given the current trajectory of substitution, about 80 percent of courses taken in 2024 will have been taught online in a student-centric way" (Christensen, Horn, & Johnson, 2008, p. 102). Their prediction is based on technology that is easier to use and cheaper than the alternative, albeit at a lesser quality with respect to the existing delivery system. As they describe there, these changes will become possible due to:

(1) technological improvements that make learning more engaging;
(2) research advances that enable the design of learner-centric software appropriate to each type of learner;
(3) the looming teacher shortage; and
(4) inexorable cost pressures. (p. 102)

Christensen and his co-authors add that online education is clearly a better alternative than nothing, which explains why in his Theory of Disruptive Innovation, technological disruption begins with non-consumers. With respect to education, as in other areas he has studied, as the technology improves, online learning will move to compete with already established venues.

Even more startling than changes in physical size and computing power that are part of the inevitable improvements to come, however, are the changes in attitudes we are seeing, as evidenced by what happened at UVA. While computing technology has advanced with the certainty of Moore's Law, less certain has been the vision of decision-makers responsible for implementing the technology in educational settings. While the technological challenges of the past four decades have been daunting, they pale alongside what I will call the philosophical challenges posed by basic human conservatism. Indeed, it was no doubt conservatism that prompted the UVA President to move with more reticence than the board thought was appropriate, given the changes in educational landscape that many see to be inevitable.

## From the Past to the Future

Returning to my experience with the *International Herald Tribune* article, as I read, I needed more details on the "debate over online education" alluded to by the reporter, so I pulled out the iPhone from my pocket for a quick Google search. With that I received more information about what had happened at UVA: "expectations are high for a rapid transformation—through costly technology—to online instruction" (Pérez-Peña, 2012).

While the cost of the technology cannot be disregarded, the price/performance ratio is miniscule when compared with the huge computers of the seventies. From eye-popping graphics display to incredible computer power that has enabled such developments as photography, video, Bluetooth and wireless access, and even voice recognition that seems to be finding a place, our pockets overflow with

computing power that overwhelms the imaginations of such visionaries as Stanford's Patrick Suppes (1966). He predicted in an article in *Scientific American* that each student would have access to a tutor akin to the situation Philip of Macedonia provided for young Alexander by engaging Aristotle.

## Conclusion

Unfortunately, Suppes's vision of an Aristotle for every learner is not yet reality, but neither have we tapped all the technological power that we carry around in our pockets, backpacks, or briefcases. While technical challenges remain, these exist more in the area of software implementation than in the sort of technical feasibility that led Secretary of Education Arne Duncan to call for all textbooks to go digital (Lederman, 2012). Unfortunately, we also see evidence that attitudes are not yet where they need to be, given that his call has been welcomed by some but panned by others. One of the primary complaints is that digital textbooks would only serve to increase the "digital divide" (Stansbury, 2012), a truly sad philosophy in its own right, given the implied reluctance to explore new tools.

Nevertheless, going forward in this space, several times each year, we will look at the sorts of things that technology should do for learning, with the assumption that we can design learning activities that for all intents and purposes are not limited technologically and that make sense pedagogically. Based on what we see going on in the technology arena, hardware and software developments seem to have placed us on the threshold that opens to a future of unanticipated uses of educational technology, one in which we are limited only by our imaginations. The key will be in designs and implementations that fit with how people learn and that respond to pedagogical pull rather than technological push.

Discussions of these issues will also take into account the assumption that for the foreseeable future, teachers will continue to do some things better than these can be done with technology. Stated succinctly, if the technology can accomplish something useful for learning, then let's not waste the teacher's time with those tasks and use the technology in those areas instead. Thus, a key focus will be an exploration of the proper mix of how the efforts of teacher and technology can be blended to not only make learning more accessible to more people but also to improve the experience that all learners can have.

Thus, we will explore innovations in educational technology as they exist or will be developed. We will begin discussions from the standpoint of technological feasibility, without assuming that just because something can be done it should be done. We will then examine architectural, logistical, and philosophical issues that will influence the potential of various innovations that can improve learning as well as affect their implementation.

The ***architectural*** considerations to be discussed will revolve around the tools used in the conception, development, and delivery of learning content as well as with the instructional interactions themselves. This area will address the capabilities made possible by new developments in software that open up capabilities of hardware for use in education.

The next category of considerations to be discussed will deal with how technology-delivered learning experiences are adopted, implemented, and evaluated. This category is labeled ***logistical*** because it implies the flow of content from the producer to the consumer/learner. That process can involve what have been the traditional middlemen such as publishers, or it might involve a rather direct connection between development and the learning itself. Learning settings can involve learners working alone, or in a hybrid setting where teachers or tutors contribute to the learning process. They can also involve learners creating tools and content that can facilitate the learning of others. In all cases the interplay of technology and the teacher/tutor/peer presents instructional design challenges with which developers and implementers alike must grapple.

The final area will deal with the fact that people are averse to change, recognizing that success in addressing stakeholder attitudes will lag behind technological advances. Thus, discussions of the resulting ***philosophical*** issues will be guided by two fundamental assumptions. First is the fact that teachers will most often tend to teach the way they themselves learned. Second, learners will most likely prefer learning in the future the same way they have learned in the past. The implication here is that technological advances that fail to take these issues into account will meet with significant resistance at all levels.

In summary, discussion will focus on those three areas: architectural (a form of software engineering for learning), logistical (channel organization for development and delivery of learning experiences), and philosophical (attitudes of developers, implementers, and learners that affect policies). These three areas will be considered individually or at times at the intersections of issues involving those conditions where two or more of the three happen to overlap. Indeed, it is at those intersections where we will find the most interesting topics to discuss as we seek to identify those ***points of inflection*** on the curve of technological development where productive changes can take place to help learners learn better in the future. □

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