Disruptive Innovation in Technology and Engineering Education: A Review of the Three Works by Clayton Christensen and Colleagues

A Comprehensive Review by Vinson Carter

Christensen, C. (1997). *The innovator's dilemma*. Boston, MA: Harvard Business School Press. ISBN: *0062060244*

Christensen, C., Horn, M., & Johnson, C. (2008). *Disrupting class: How disruptive innovation will change the way the world learns*. New York: McGraw-Hill. ISBN: *0071749101*

Christensen, C. & Eyring, H. (2011). *The innovative university: Changing the DNA of higher education from the inside out.* San Francisco, CA: Wiley. ISBN: *1118063481*

As a teacher and a teacher educator, when I hear the term disruptive innovation or disruptive technologies, my thoughts are immediately drawn to the ring of a cell phone or other electronic devices that might essentially be a disturbance in the classroom. Although these devices may in fact be considered disruptive innovations, there is a deeper level that must be examined to see how disruptive these innovations might be in the future and how they might change the course of education forever.

In 1997, Clayton Christensen wrote a book entitled *The Innovator's Dilemma*. In this book, Christensen identified the differences between sustaining and disruptive technologies. He discussed how the pace of progress in business typically precedes the markets awareness of need and how the very qualities that make businesses successful may hinder their ability to predict, identify, and manage disruptive innovation.

In many ways, Christensen has reexamined progress in the business world, just as Thomas Kuhn explored change within the scientific community with his idea of paradigm shifts in *The Structure of Scientific Revolutions* (1962). Since his first book, Christensen has gone on to co-author multiple books examining disruptive innovation in health care and education as well as ways to predict and provide businesses with tools to deal with disruptive technologies.

According to Christensen, a *disruptive technology* is an innovation that results in worse product performance but is popular because of its simplification, affordability, and convenience, among other things (1997). Conversely, *sustaining innovations* happen within an existing market. Sustaining innovations typically solve problems using new technologies without creating a new market (1997). However, disruptive technologies have the ability to cause radical

changes due to their availability outside of existing markets and their gentle learning curve for consumers. Given that disruptive technologies start small and with a segment of the market that is generally overlooked, they have the ability to be constantly improved upon, until they are able to overtake an existing market. Christensen (1997) gives several examples of disruptive innovations in his book, three of which follow.

In the 1980s, Digital Equipment Corporation (DEC) was leading the way in the minicomputer market with their sustaining innovations. They knew their product and their customers and were a thriving business, even "at one time regarded as among the best-managed companies in the world" (p. 8). By 1989, however, DEC was on the verge of collapse. Many in the business world were shocked that DEC had not been able to foresee the personal computer heading into the mainstream. This is the same business with the same managers that had been considered so successful just a few years previous. It wasn't that DEC was not aware that the personal computer was gaining ground quickly in the computer industry, but the personal computer did not fit their corporation's current business model. Michael Horn would say that the DEC managers probably asked themselves, "Should we build better products for our best customers for even better profits, or should we build worse products that our customers can't use and won't buy for profits that will kill our business model?" (Horn, 2010).

Personal computer companies like Apple were able to greatly disrupt the minicomputer world in the 1980s. Apple "was uniquely innovative in establishing the standard for user-friendly computing" (p. 8). Apple computers were designed for a market that did not exist. Their first computers would have been considered completely worthless to minicomputer users. Slowly, Apple was able to improve their product outside of this existing market until their product was able to fulfill the needs of those customers.

Another example of disruption is when Toyota introduced low-priced, fuel-efficient cars into the North American marketplace. The Japanese automakers were able to disrupt the American automakers as they continued to improve their vehicles by developing more sophisticated cars that competed with the American market. Entrants into the low end of the automobile market such as Hyundai are now forcing disruptive innovation of "simpler, more convenient transportation" (p. 165) upon those same Japanese companies. Christensen makes it clear that "at a deeper level …. There are times at which it is right not to listen to customers, right to invest in developing lower-performance products that promise lower margins, and right to aggressively pursue small, rather than substantial, markets" (p. 9). Often the pace of technological progress precedes the market's awareness of a need that over time might be satisfied through a disruptive innovation.

The way that a business approaches disruptive innovation can be examined through an appraisal of that organization's capabilities and disabilities

(Christensen, 1997). He has identified the three main facets or *intrinsic conflicts* that affect an organization's ability to manage change as "its resources, its processes, and values" (p. 129). All businesses have a unique set of values or company culture that may affect its allocation of resources and implementation of processes. The resources a business allocates may help managers identify how effectively changes within an organization may transpire.

> One of the dilemmas of management is that, by their very nature, processes are established so that employees perform recurrent tasks in a consistent way, time after time. To ensure consistency, they are meant *not* to change—or if they must change, to change through tightly controlled procedures. *This means that the very mechanisms through which organizations create value are intrinsically inimical to change* (Christensen, 1997, pp. 130–131).

Because of an organization's inflexibility to change its normally profitable business infrastructure, its immediate response when a disruptive technology emerges is to cram this innovation into the existing model for their current customers (Christensen, Horn, & Johnson, 2008). Christensen is clear that businesses must be mindful of the intrinsic conflicts when dealing with disruptive innovations. Sometimes the weaknesses of disruptive technologies may actually be their strengths, in that they do not have to compete in a mainstream market. In order to be successful when dealing with these disruptions, businesses "need to create a context in which each organization's market position, economic structure, developmental capabilities, and values are sufficiently aligned with the power of their customers that they assist, rather than impede, the very different work of sustaining and disruptive innovators" (Christensen, 1997, p. 174). Often, organizations that have been successful in meeting disruptive innovation head-on have had the ability to create a spin-off organization that is autonomous from the mainstream company (Christensen, 1997).

What Does This Mean for Education?

Teachers and schools in the United States have come a long way from their humble beginnings in the one-room schoolhouse. In the book *Disrupting Class*, Christensen, Horn, and Johnson suggest that as U.S. schools began this evolutionary progression, schools standardized through a process that was inspired by the "efficient factory system that emerged during industrial America" (2008, p. 35). They go on to describe and compare education to the *factory model* in which students are taught in the same fashion, noting that, "the students who succeed in schools do so largely because their intelligence happens to match the dominant paradigm in use in a particular classroom—or somehow they have found a way to adapt to it" (p. 35). Many studies have shown that teachers tend to approach teaching their students in the same manner or setting in which they feel the most comfortable (Stewart, Jones, & Pope, 1999; Orr, Park, Thompson, & Thompson, 1999). Christensen, et al. (2008) claim that

"students who naturally enjoy the teaching approach they encounter in a given class are more likely to excel" (p. 36), so we must find a way to move toward … a 'student-centric' model" (p. 38).

The student-centric model of learning described in the book *Disrupting Class* is an excellent example of what may be possible "through disruptive implementation of computer-based learning" (Christensen, et al., 2008, p. 45). Often, technologies, especially computers, have been added into the classroom, but the method of instruction remains the same. The teacher is still the primary source for content delivery, and the computers are used as an addition to the factory model of traditional instruction. As the demand for computer-based learning and online classes grows, the authors feel that these disruptive tools will help students learn content in the classroom in a more meaningful way that is representative of their specific learning style or styles.

"Public education enrollments in online classes … are exhibiting the classic signs of disruption as they have skyrocketed from 45,000 in 2000 to roughly 1 million today" (Christensen, et al., 2008, p. 91). According to Christensen, et al., there will likely be a transition from the traditional teacher-led classroom where instruction is delivered through computer-based learning to a model where software will become the primary mode of delivery. In this model, the teacher will serve as a facilitator who can provide much needed one-on-one instruction for students who may be struggling. It is interesting to note that the system outlined by Christensen, et al. sounds very similar to the modular system used in technology education during the 1980s and 1990s.

According to Christensen, et al. (2008), "the data suggest that by 2019, about 50 percent of high school courses will be delivered online" (p. 98). With this in mind, educators must prepare to meet this challenge with an open mind and look to disruptions that may be taking place in the present for guidance in preparing for the future. This may involve the reinvention of our current educational system and a re-evaluation of the way that teachers develop and deliver instruction.

New Markets for Disruptive Innovations in Education

Christensen, et al. (2008) have found a major difference in identifying disruptive innovations in education as opposed to businesses. They state that "public education is set up as a public utility, and state laws mandate attendance for virtually everyone. There was no large, untapped pool of non-consumers that new school models could target" (p. 60). However, they have identified homebound, home-schooled students, students that need credit recovery, and pre-kindergarten as potential areas of non-consumption.

As schools struggle to meet the demands of No Child Left Behind, resource allocation and test scores have become a top priority. Often this means that schools must prioritize the classes that they are able to offer students.

> A casualty of this resource allocation has been many of the "nice-to-have" courses – in the humanities, languages, arts, economics, statistics, and so on. Diminishing supply in such courses means growing non-consumption in these areas. In an odd way, this is good news actually. Computer-based learning is a welcome solution when the alternative is to forgo learning the subject altogether (Christensen, et al., 2008, p. 93).

Unfortunately, technology and engineering education may fall into this "nice-to-have" category. Technology and engineering education is often overlooked as an "equal partner in general education," and its value is often scrutinized by those outside of the profession (De Miranda, 2004). Clark (1989) described the traditions of the industrial arts profession as something that may have slowed progress to a more modern, technology-based model of education. As Christensen, et al. (2008) suggest, those of us in the technology and engineering profession may have to rethink how we might make this shift through the power of disruptive innovation to deliver technology and engineering education to all students in the 21st century. Perhaps this will provide the technology and engineering education profession with a chance to redefine itself in the general education community (Sanders, 2001).

In order for disruptive technologies to be successful, they must be implemented in programs and schools "where the alternative is nothing" (Christensen, et al., 2008, p. 74). According to the authors, carefully selecting where to apply these disruptive innovations is far more important than the technologies themselves. Determining when and where these disruptive innovations should be incorporated is vital to the progress of schools as educators attempt to maintain quality instruction in today's ever-changing world.

One of the suggestions by Christensen, et al. is that student-centric, computer-based model schools be implemented in a manner that is strikingly similar to what we might know as the modular approach to technology and engineering education. They seem to believe that this modular approach will allow for the most convenient and effective means to serve the needs of students. This modular approach "opens the system to enable competition for performance improvement and cost reduction of each module" (Christensen, et al., 2008, p. 31). Although Christensen and his colleagues acknowledge that corporations, like textbook publishers, often have too much deciding power in what and how content is taught in the classroom, they do not specifically accept that the competition for modular learning models might have this same effect. As Petrina (1993) highlighted in his critique of modular approaches to teaching technology education, sometimes the "corporate values and market interests" might amount to "company views of the technological world" (p. 77). Is this what should be shaping our educational system? Petrina is adamant that these modular approaches are "no match for the practices of an imaginative and resourceful teacher with a grounding in contemporary educational theory, who

can plan, design and redesign curriculum; and understands the difference between merely doing and a contextually rich educative experience" (1993, p. 78).

What Does This Mean for Higher Education?

In order for disruptive innovations to be successful in K–12 schools, the concept of these innovative technologies should be introduced in teacher education programs in post-secondary institutions. The importance of adapting to change, whether to disruptive technologies or something else, is a vital skill for educators to attain. If teacher education programs, especially in technology and engineering education, could introduce, grow, and nurture the development of disruptive technology implementation, teachers would be more willing to attempt to utilize some of these techniques. Unfortunately, there is an unfulfilled need for disruption even in higher education.

One reason for this is simply the absence of disruptive innovation. From the very beginning of post-secondary education, "learning technologies—lectures, textbooks, oral and written examinations—have remained largely the same" (Christensen & Eyring, 2011, p. 18). Several factors affect the lack of disruptive innovations in higher education, as the authors suggest that "fundamental change has been unnecessary" (p. 18). In times of financial crisis due to economic downturn, public universities have been able to weather the storms because of taxpayers, alumni support, and legislative backing. Christensen and Eyring (2011) suggest that this is no longer the case for most higher education institutions due to higher costs and new ever-emerging competitors. Even at this level, online courses are a current disruptive technology that is forcing universities to re-evaluate the traditional higher education system.

Christensen and Eyring (2011) use Brigham Young University (BYU) - Idaho as an example of an institution that might be seen as leading the way as a disruptive model in higher education. In 2000, BYU-Idaho went to a year-round academic calendar in order to serve more students throughout the year. They also eliminated their athletic programs, decided to focus on serving only undergraduate students, offering online programs of study, and changing their focus from discovery research to the scholarship of teaching. As noted in the book *The Innovative University*, this is a serious alteration "of the traditional university DNA" (Christensen & Eyring, 2011, p. 27). The traditional university student attends classes on a campus that embodies the whole collegiate experience. This experience includes peer groups, dorm life, athletics, and the specific *brand* of the college. Often this brand or image is strongly influenced by activities associated around college sporting events (Toma & Cross, 1998).

Christensen and Eyring (2011) are quick to point out these traditions may shift through the employment of disruptive innovations in higher education and that "as the diploma mill stigma of online education fades and the high end of the market becomes saturated with competitors, the premier online companies

have the option of lowering price to attract even brand-conscious students" (p. 215).

Conclusion

Two opportunities that may help sustain our profession have emerged in recent years. The first of these opportunities is the increased emphasis and funding that is available in science, technology, engineering, and mathematics (STEM) education. The President's Council of Advisors on Science and Technology Executive Report (2010) details the nation's need for a strong STEM workforce with skills necessary to compete in our ever increasingly technological world. The other opportunity is in the new Framework for K–12 Science Education (2011). This framework places a heavy emphasis on technology, engineering, and design. We can look at both of these disruptions in the technology and engineering education profession as opportunities for grounding the delivery of technological literacy to a larger audience.

As we have seen, disruptive innovations have greatly influenced the course of history, from the computing industry to the automotive industry. There are disruptive innovations challenging K–12 education as well as higher education at this very moment, and the technology and engineering education profession must be proactive in our research and development of these innovations. As Christensen and his colleagues point out, we must remain flexible and be mindful of those intrinsic conflicts that may hinder our ability to effectively manage change. We must harness the potential power of our resources, processes, and values that strengthen our profession.

Additional research should be conducted to determine how the technology and engineering education profession must prepare for the inevitable disruptions in the future of education. It is also important that attention be given to how disruptive innovations might also be challenging professional societies.

References

Christensen, C. *(1997). The innovator's dilemma*. Boston, MA: Harvard Business School Press.

Christensen, C., Horn, M., & Johnson, C. (2008). *Disrupting class: How disruptive innovation will change the way the world learns*. New York: McGraw-Hill.

Christensen, C., & Eyring, H. (2011). *The innovative university: Changing the DNA of higher education from the inside out.* San Francisco, CA: Wiley.

Clark, S. C. (1989). The industrial arts paradigm: Adjustment, replacement, or extinction? *Journal of Technology Education, 1*(1), 7–21. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v1n1/clark.jte-v1n1.html

De Miranda, M. (2004). The grounding of a discipline: Cognition and instruction in technology education. *International Journal of Technology Education and Design Education, 1*(4). 61–77.

Horn, M. (Presenter). (2010, May 26). Disrupting Class [Episode 8]. *MIT World Lecture Series.* Podcast retrieved from http://itunes.apple.com/us/podcast/disrupting-class-how-disruptive/id382420793?i=88304367

Kuhn, Thomas, S., (1962). *The Structure of Scientific Revolutions* (2nd Ed.). Chicago, IL: University of Chicago Press.

National Research Council. (2011). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=13165

Orr, B., Park, O., Thompson, D., & Thompson, C. (1999). *Learning styles of postsecondary students enrolled in vocational technical institutes.* Journal of Industrial Teacher Education, 36 (4), 5–20.

Petrina, S. (1993). Under the corporate thumb: Troubles with our MATE (modular approach to technology education). *Journal of Technology Education, 5*(1), 72–80.

President's Council of Advisors on Science and Technology. (2010). *Prepare and inspire: K–12 education in science, technology, engineering, and math (STEM) for America's future.* Retrieved from *www.whitehouse.gov/sites/default/files/.../pcast-stemed-report.pdf*

Sanders, M. (2001). New paradigm or old wine? The status of technology education practice in the United States. *Journal of Technology Education 12*(2). 35–55.

Stewart, P. H., Jones, V. N., & Pope, J. V. (1999). *Learning styles: Charting with iconic learners*. Retrieved from ERIC Record Details - ED42840.

Toma, J. D., & Cross, M. (1998). Intercollegiate athletics and student college choice: Exploring the impact of championship seasons on undergraduate applications. *Research in Higher Education 39(*6). 633–661.

Vinson Carter (vcarter@uark.edu) is Instructor of Technology Education in the Department of Curriculum and Instruction at the University of Arkansas.