**The impact of disruptive information and communications technologies on universities**

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Research universities are under attack in virtually every jurisdiction in which they operate in advanced industrial democracies. The issues in this crisis are many, diverse, and often contradictory: funding models that are antiquated; cutbacks in government subsidies; tuition rates that are either too high or too low; expensive infrastructure that needs maintenance; costly equipment that cannot be easily replaced; students and employers interested only in practical skills training rather than in a broad, general, adaptable education; professors who must publish or perish on the road to tenure and who do not focus attention on their pedagogical approaches to teaching students; classes that are too big; too many classes that are too small; administrative apparatuses that are unjustifiably large and growing; Byzantine bureaucratic rules; and, disruptive uses of emerging technologies that have the potential to erode the foundations on which higher education has been built.

A treatise could be written, and many have been, on each and every one of these issues. Here, however, I want to concentrate on the last one, the emergence of highly disruptive technologies and their impact on university education. There are four aspects that deserve serious consideration in this regard.

First, the generation of students who are about to enroll in programs of study at research universities are what some commentators have labeled “digital natives” or “the born digital generation”. They are at ease with computers, touch screens, and smart phones in ways that make their parents, and certainly their grandparents, both proud and envious. Familiarity with these technologies affects the way digital natives think, study, and learn. So, how have universities prepared themselves for the arrival on their campuses of this born digital generation? Not well, I am afraid, is the answer. Our pedagogical approaches have still not adapted to this new style of learner and the new tools used to master

materials. Professors are rarely given the opportunity to think about and improve their teaching, and they rarely teach with explicit learning objectives based on the experiences and expectations of the students in their classes. Universities have a lot of work to do on this front.

Second, the born digital generation has grown up in an environment in which vast stores of information are readily available on the Internet and the means of accessing these data are ubiquitous. The size and scope of browser-based searches across the World Wide Web is nothing short of mind-boggling. Unfortunately, this data is not of uniformly high quality. Rather, more often than not, it leaves much to be desired. How do digital natives know which information is valuable and correct and which is questionable on both counts? At universities, professors create much, if not most, of the truly useful information available on the Web. But finding it can be a daunting task. The profession of librarian is constantly being reinvented to address these matters. But changing bad habits is very tough. Librarians and pedagogues must work together with professors to help students sort the data on the Internet and World Wide Web to allow them to transform it into useful information. Professors' research and the very nature of research itself have to become part of the value-proposition for undergraduate students who attend research universities. Research and teaching must be seen as complementary and librarians have to be identified as key resource personnel.

Third, the traditional physical design of classrooms does not encourage deep engagement with the process of learning. Active participation is required in order for learning to be most effective. Indeed, active learning rarely takes place in the lecture hall or when the only speaker in a seminar is the professor. If the technology is appropriately deployed and the information readily available, then why don't we just flip the procedures: record the lecture and make the relevant reading and exercise materials available to students BEFORE they come to class, and then use class time to focus on the specific learning objectives. In order to do this, we need planners, designers, and architects to consider

learning styles and information needs of digital natives so that professors can adapt physical spaces to fully engage students as active learners. Once again, professors and administrators know what we need to do, but we are not doing it fast enough or deep enough.

Finally, given the technology, information, and pedagogy, one might ask why the community of active and engaged learners be created that extends far beyond the walls of the classroom or the gates of the university? There have already been some exciting and challenging experiments with higher education materials, but until recently many have originated outside of the university. The concept to which I am referring here is called a MOOC, a "massive open online course". These are not just "canned" courses or recorded "talking heads", but rather entirely new ways of packaging materials, conducting assessments, and ensuring quality, in order to teach incredibly large numbers students, with success. The economies of scale are incredible – forget teaching a 1000 student introductory course, MOOCs can reach hundreds of thousands of learners, potentially millions, with a single offering. The challenge is that many such enterprises which can, and do, offer quality products for interested and motivated learners are not directly affiliated with traditional institutions of higher learning, although they all use highly renowned professors from world-class universities to design, develop, and deliver MOOCs. Universities can learn a lot from these groups, and already are doing so. This includes creating not-for-profit consortia that plan to learn how to improve the residential campus experience for digital learners by experimenting with MOOCs.

Taken together, these four trends, based on disruptive information technologies, represent a truly significant challenge for universities. Research universities can continue to be relevant to born-digital generations only if they take pedagogy seriously, enlist librarians to help students transform raw data into useful information and knowledge, convert traditional classrooms into active learning spaces,

and deliver MOOCs in such a way as to make the experiences transferable to the on-campus face-to-face environment in which professors' research feeds directly into the course.

If universities, especially public research universities, are to survive into the twenty-second century of the Common Era, they will have to be creative in responding to the political, economic, and personal criticisms levied at them and in adapting to new expectations of students who are "digital natives", and they will have to respond to "startups" entering the higher education arena. If universities were traded on the futures market, I would only buy stock in those that are addressing all four of the issues I have outlined above. I am pushing the one at which I work to do just that.