


TRAJECTORIES FOR DIGITAL TECHNOLOGY IN HIGHER EDUCATION

“We look at the present through a rear-view mirror.
We march backwards into the future.”

—Marshall McLuhan

By Malcolm Brown



When we consider the future roles of digital technology in higher education, it is often helpful to think in terms of *trajectories* rather than predictions. Predictions are remarkably fragile things. Any unforeseen factor will render the prediction false or off-target, and as those variables increase, so too does the likelihood that the prediction will fail. Predictions also tend to be projections of the current and the known, ornamented with something that provides a futuristic hue. In the case of digital technology, given the acceleration of change—enabled by the very things whose course we are trying to predict—the conundrum of predictions may be at its most acute.

It is thus more practical to work with trajectories. With a trajectory, we know where something is headed, but we cannot say—or we refrain from guessing—where it will end. Working with trajectories is an admission that we cannot foresee the unanticipated factors and developments that might influence the trajectory, accelerating it or perhaps instead derailing it entirely. In this sense, working with trajectories is a more humble and realistic way of facing the future. A trajectory is also far less fatalistic than a prediction. The latter asserts that this is where we *will* end up, whereas a trajectory shows where we *might* end up.

In terms of teaching and learning, I would like to suggest three characteristics that provide context for the following discussion of six digital technology trajectories. The first characteristic is *personalization*: the growing capabilities and willingness to use digital resources to create custom pathways for learning and degree success. One of the clearest illustrations of developments in this area may be MIT's exploration of breaking its courses down into modules and enabling students and instructors to "reassemble" the modules to construct personalized educational pathways—a process likened to constructing a playlist in iTunes.¹ Developments such as these lend credence to the suggestion that we have entered the "post-course era" in higher education: the course is no longer the curricular atom or fundamental building block.²

The second characteristic is the *adoption of hybrid learning models*.³ The footprint of the online dimension is expanding across all venues of higher education, including institutions that have traditionally valued intimate, face-to-face learning.

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Higher education's "affair" with the MOOC, though now waning, has had one lasting impact. It has greatly accelerated the migration of higher education into online education.⁴ In addition, this characteristic is intertwined with the first as instructors, instructional designers, and students are starting to invent and modify learning models and pathways as needed to achieve more personalized learning goals.

The third characteristic is the *analysis of ever-increasing amounts of data* and the increasing influence those analyses have in the conduct of higher education. This use of "big data" affords much more nuanced and timely insights into all kinds of learning processes. It enables the creation of custom reports tailored to specific learning contexts, ranging from institutional dashboards to personalized assistance for learners. It provides the basis for measuring progress toward institutional strategic goals. Equally important, analytics enables interventions in nearly real time. This contributes greatly to learner and instructor success, as it allows the institution to assist students at the very moment they are falling behind.

Clearly, digital technology is the fabric of nearly everything associated with teaching and learning. We can think of this fact as an overarching trajectory: digital technology is the core strategic enabler of learning in higher education. But there's a twist. Our thinking about digital technology in higher education is shifting away from seeing it as IT *infrastructure* and instead toward conceiving it as a *digital learning environment*.⁵ For those of us who have worked in higher education information technology, this is a significant shift in our thinking. It means that the technology is no longer in the foreground; instead, our

attention is focused on the learners and the learning experiences that the technology enables.⁶ It sets for all campus players the ambitious goal of a learning ecosystem that is responsive and can be personalized. Enabling that ambitious goal are six individual trajectories of digital technology: device ownership and mobile-first; the textbook and open educational resources (OER); adaptive learning technology; learning spaces; the next generation learning management system (LMS); and learning analytics and integrated planning and advising services (IPAS).

Device Ownership and Mobile-First

In the past, there was much discussion of the digital divide: the situation in which some students were able to afford digital equipment whereas others could not. Although the problem has not been fully resolved, the picture has shifted. The combination of lower costs for hardware and the mobile computing revolution of the past decade has altered the landscape. Mobile computing is a key technology in teaching and learning, and the trajectory is that it will continue to be so.

One way to appreciate this trajectory is by taking a look at results of the annual student study conducted by the EDUCAUSE Center for Analysis and Research (ECAR). In 2004, the study revealed that student technology ownership was divided between desktop and laptop computers. Most students owned only a single device. The ownership of "personal digital assistants" was just under 12 percent. If we jump to the most recent studies, we see how thoroughly this landscape has changed. According to the results of the 2013 study, 30 percent of the respondents owned 4 or more Internet-capable devices. In 2013, ownership of smartphones and tablets had increased by 14 percent and 15 percent, respectively, over the previous year. According to the 2014 study, ownership of smartphones jumped to 86 percent and is projected to be 90 percent in 2015. Tablet ownership in 2014 jumped to 47 percent, and its 2015 trajectory is 58 percent ownership.

Significantly, the percentage of students using these devices directly for academics is increasing: moving from roughly 50 percent (2013) to 70 percent (2014) for smartphones and from 12 percent to close to 50 percent for tablets.⁷

Such ubiquity enables institutions to leverage the mobile environment. Many are moving to a mobile-first approach. One of the first schools to move to mobile-first was Abilene Christian University, which has integrated mobile technology into its courses. Lynn University is moving its LMS functionality off the traditional LMS application and onto a component-based approach, one informed by this mobile-first approach. Tennessee Technical University's Mobile Learning Environment and Systems Infrastructure (MoLE-SI), first introduced in the College of Engineering, is now poised to be introduced more broadly throughout the curriculum.⁸

Mobile technology affords students and instructors an unprecedented degree of independence from the campus IT organization. Certainly they need campus networking, but even here, their cell phone connectivity can provide Internet access. It is helpful if the campus has an agreement in place for Google Docs, but if it doesn't, they can use Google Docs anyway. The use of apps, such as VoiceThread for audio annotations or Diigo for collaborative tagging, requires neither permission from nor enablement by the campus IT organization, again apart from networking. To access resources from iTunes U or to participate in a MOOC requires only the campus network; instructors' and students' devices do the rest. Hence mobile technology permits students and instructors to personalize their environment, which

puts their relationship with the campus IT organization on a slightly different footing.

The Textbook and Open Educational Resources (OER)

This trajectory is surprising. The textbook is undergoing a remarkable bit of evolution: it's vanishing, at least in its traditional form as a book whose text is furnished by a third-party company and is sold at the campus bookstore. As paradoxical as it sounds, this is due largely to the companies that have in the past provided textbooks for higher education, companies such as McGraw-Hill, Cengage Learning, and Pearson. These companies are coming to see that profits lie in adding value to the core text and not in providing the texts themselves. According to Michael Feldstein, these companies "just want to be out of the *textbook* business. They want to sell software and services that are related to educational content, like homework platforms or course redesign consulting

services." Jonathan Band similarly noted that the textbook publishers "are well aware of the expanded competition presented by the Internet, and have begun to adjust their business models accordingly. Pearson, for example, is shifting from the supply of educational *materials* to the provision of education *services*. Such services include testing, assessment, student information systems, and course management platforms."⁹

One dimension of this trajectory is the decline in the purchase of commercial textbooks, driven largely by their increasing costs. According to information from the U.S. Census Bureau, the price of textbooks rose 812 percent between 1978 and 2012. By contrast, over the same period, the cost of medical services rose 575 percent,

new home prices 325 percent, and the consumer price index 250 percent.¹⁰ This has motivated students and instructors alike to seek alternatives. According to the ECAR 2013 student study, 71 percent of students used OER in 2013 (up from 25 percent in 2010) and 54 percent said that open resources are extremely important. The ever-growing abundance of ancillary content relevant to education (e.g., iTunes U, MOOCs, and repositories such as OpenStax CNX) enables students to skip the purchase of core textbooks altogether and instead seek basic explanations of content from these open resources. The course textbook is no longer a requirement but, rather, an option.

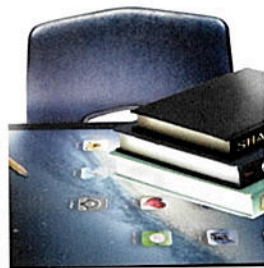
There are also initiatives entirely devoted to enabling students to create their own custom course content, largely from OER. The company Boundless (<https://www.boundless.com>) will mimic the table of contents of a commercial textbook and supply OER alternatives for each chapter of the book. A Pearson project (<http://www.pearsonhighered.com/collections/>) uses a specially designed search engine, called Gooru, to enable anyone to find appropriate OER. As an indication of how rapidly untraditional all of this is becoming, this is a Pearson project, but at the same time, Pearson is one of the major companies suing Boundless.¹¹

This trajectory seems to counsel us to expect that the classic higher education textbook will vanish, replaced by a variety of resources, the most important of which is OER. We may also expect that the traditional commercial companies will continue to invest in services such as adaptive learning technology (see the following section).

Adaptive Learning Technology

Situated "next door" to OER is adaptive learning technology.¹² This appears to be the core service that publishers are betting on. Adaptive learning technology is in its start-up phase, much as where learning analytics technology was two years ago. Although its trajectory is not fully established, adaptive learning technology

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certainly has the potential to exert a forceful influence on teaching and learning over the next three to four years.

Adaptive learning technology takes a “non-linear approach to instruction and remediation, adjusting to a learner’s interactions and demonstrated performance level and subsequently anticipating what types of content and resources learners need at a specific point in time to make progress.”¹³ It is, then, a kind of automated tutor. What is fascinating is how quickly the major textbook publishers have cast an anchor into this technology:

- Pearson has teamed with Knewton, enabling Pearson to offer its MyLab and Mastering adaptive learning tools for a broad range of subjects, mostly in the sciences.
- McGraw-Hill has introduced ALEKS and Smartbooks, the latter based on its LearnSmart adaptive technology.
- Macmillan’s New Ventures division has a partnership with Knewton and has access to PrepU’s technology.
- Wiley has announced a partnership with Snapwiz to produce a new product offering called WileyPlus.

There are other companies and even universities in the mix here as well:

- The companies include Smart Sparrow, CCKF, and ScootPad.
- Brightspace by D2L acquired the startup Knowllege and its adaptive learning technology called LeAP.
- In Europe, roughly a dozen institutions have formed INTUITEL, with the objective “to enhance e-learning content and Learning Management Systems (LMS) with features that so far have been provided only by human tutors.”
- The University of Phoenix has invested considerably in its adaptive learning technology Academic Activity Stream.
- Professors at Ohio University created an adaptive learning module (called MOOCulus) that they grafted onto the Coursera platform for their MOOC on calculus.

Adaptive technology has established a beachhead in higher education practice. Notable early projects include Arizona State University’s use of Pearson’s MyLab and Essex Community College’s use of ALEKS.¹⁴ Reports from these projects are mixed, as is to be expected with a young technology that is just getting going, but the blend of considerable interest¹⁵ and investments promises to make this a key technology for the foreseeable future.

Learning Spaces

Learning spaces is an umbrella term referring to the physical spaces specifically designed to accommodate learning activities, including (but not limited to) formal classrooms, the learning commons, labs, and makerspaces. The trajectory here, as explored more fully by Mark Valenti in his article in this issue of *EDUCAUSE Review*, “Beyond Active Learning: Transformation of the Learning Space,” is that these spaces are evolving away from being places of presentation and toward being places of discovery, invention, and knowledge construction.¹⁶

The makerspace is perhaps the clearest example.¹⁷ Currently makerspace rooms are places for invention using physical objects. Often these rooms house a variety of equipment, available to students individually or in teams. As always, technology provides a very wide range of possibilities. 3D scanning and printing technologies are common to almost all makerspaces, enabling students to capture and reproduce objects in three dimensions. Programmable circuit boards, such as Arduino and Raspberry Pi, enable a variety of projects. Some schools, seeking to enable as wide a range of projects as possible, provide equipment such as sewing machines, miter saws, computerized routers, 3D microscopes,

large sheet printers, oscilloscopes, and soldering irons. The idea is to provide raw materials and tools to foster discovery and invention.¹⁸

This trend toward discovery, content sharing, and knowledge creation is not limited to makerspaces but also informs formal and informal learning space design, and once again digital technology is the enabling agent. Wireless projection is a good example. Until recently, access to projection on the main classroom screen was limited to the person at the podium, reinforcing the message that the classroom was more about presentation than participation. But institutions are increasingly installing wireless projection capabilities, which enable any participant, appropriately equipped, to project his/her material on the main screen. Wireless projection also allows the instructor to roam the room, controlling the display of his/her content using a tablet.

Technology further enables team-based classroom design, also called scale-up or active learning classrooms (see, e.g., <http://scaleup.ncsu.edu/>). Traditional classroom design provides seats arranged

in rows, with a podium for the instructor at the front. This design is informed by the idea that the primary purpose of the room is to enable presentations by the instructor. By contrast, team-based classrooms provide seating at circular tables, with six to ten seats per table. Most often the room has no “front” in the traditional sense. The team-based room is designed to make collaborative student work the focus of face-to-face class sessions. The instructor functions more as a guide or mentor and less as a presenter. Students, in teams, learn by actively working in collaborations and partnerships. These designs are enabled by extensive wireless

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networking, display screens distributed around the room, room-wide access to electrical power, and mobile furniture.

The learning space trajectory clearly embodies the “new” priorities of learner-centeredness, the social/collaborative dimensions of learning, and the importance of active learning engagements.¹⁹ The built environment is particularly conspicuous, both because of its cost and because it physically affords certain kinds of usage while discouraging others. Classrooms are “architectural embodiments of educational philosophies.”²⁰ The new classroom designs offer clear evidence that the trajectory is indeed moving away from presentation and toward knowledge construction by all course participants.

The Next Generation Learning Management System (LMS)

Much like an institution's student information and fiscal administration applications, the LMS is now a fixture of the higher education technology landscape. Since its inception in 1997, the LMS has matured to the point that nearly every higher education institution runs at least one LMS. A 2014 ECAR study revealed that the current model of the LMS has been very effective—both in its design and in the way faculty use it—for the administration of learning, especially in the conduct of a course. According to the study, 99 percent of institutions have an LMS in place, and on average, 85 percent of faculty use it, whereas 56 percent of students report using the LMS in most if not all of their courses. For postsecondary teaching and learning, this level of adoption is unprecedented. But in contrast to these high numbers, the percentages of students and faculty who use the more advanced LMS features are low. According to the ECAR study: “Faculty and students value the LMS as an enhancement to their teaching and learning experiences, but relatively few use these systems to their full capacity.”²¹

In spite of these high adoption percentages, there is widespread impatience with what we might call the “LMS 1.0.”

The trajectory here is the collective anticipation of, and investigation into, an entirely new model for this function—one that is, from the ground up, learner-centered, unlike the LMS 1.0's orientation around the instructor and the course. The community is clearly seeking to replace the current LMS with a robust and comprehensive digital learning environment. As the ECAR study reports, 15 percent of institutions intend to replace their LMS in the next three years.²² Compared with the turnover rate of administrative enterprise applications, this is a significantly large percentage, suggesting a fair degree of restlessness.

What would an “LMS 2.0” look like? EDUCAUSE, in partnership with the Bill & Melinda Gates Foundation, has been conducting research into this very question, as outlined further in an article in this issue of *EDUCAUSE Review*: “What's Next for the LMS?”²³ To achieve this next version of the LMS, however, higher education will need a new paradigm. In the past, the instinct of the IT community, when confronted with a challenge like this, would have been to build a new and “large” enterprise application to meet the new requirements. But it is no longer clear that this traditional approach will work. The construction of a single application assumes that one design can meet the needs of the majority of schools, instructors, and students—an idea that seems dubious, especially in a post-course era in which personalized, custom education pathways are emerging as the priority.

One sign of out-the-box thinking about the future LMS is the formation of Unizin (<http://unizin.org>), a consortium of universities “coming together in a stra-

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tegic way to exert greater control and influence over the digital learning landscape. [Unizin] enables each institution, its faculty, and students to draw on an evolving set of tools to support digital learning for residential, flipped classroom, online courses/degrees, badged experiences for Alumni, or even MOOCs if desired. Unizin supports the differing missions and strategies of universities.” Almost exactly a decade ago, at a similar moment of restlessness with the LMS, several higher education institutions pooled resources to build their own LMS application, called Sakai. Today, Unizin is taking a very different approach: it consists of a set of pooled resources and volume-purchasing discounts. The key is Unizin's goal to facilitate the promotion of a digital learning environment, while at the same

time recognizing that institutions will have different cultures and priorities. Each institution in the Unizin consortium will blend the components in a way that is appropriate to its culture and its strategic ambitions.

Learning Analytics and Integrated Planning and Advising Services (IPAS)

All analytics for teaching and learning is intended to increase student success. A key ingredient is sustaining student “momentum.”²⁴ Research indicates that students who experience early success in a learning endeavor tend to complete courses and degree programs at higher rates. By contrast, students who do not have early success are much more likely not to complete their courses and degrees. It is also now becoming clear that students

who are metacognitively participatory in their learning achieve higher success rates than students who are not. Analytics for teaching and learning seeks to promote learner success by providing near real-time information to instructors and advisors, helping them build and sustain positive learner momentum. Student-facing analytics also seeks to address the metacognitive dimension by providing data to the learner so that he/she has a more objective basis for learning decisions. I will focus here on two types of analytics for student success: (1) *learning analytics*, which enables instructors and students to monitor engagement and progress at the course level; and (2) *integrated planning and advising services* (IPAS), an enterprise-level technology that blends data from a variety of campus systems.

Learning Analytics

The adoption of learning analytics has been accelerated by the integration of these capabilities into the major LMSs. This enables a campus to license a learning analytics module, flip the “on” switch, and quickly provide this service. For example, Blackboard, D2L, and Canvas have released learning analytics modules for their LMS applications (all called “Analytics,” as in “Blackboard Analytics” and “Canvas Analytics”). All of these modules provide similar capabilities: identifying at-risk students, measuring student engagement and participation, and offering ways to see which curricular activities seem to be producing the best results.

Although integration with the core LMS makes the task of providing learning analytics services relatively straightforward, questions remain. One question is what use students, instructors, and advisors will make

of the information. In the past, most instructors have confined their use of the LMS to its more basic functions. Another question is how much support will be provided to conduct the interventions needed when a student is flagged as being at risk. A final question concerns the sophistication of learning analytics. Some object that the current set of mainstream learning analytics functions, such as counts of how often a student logs into a course website, is at best only a proxy for how much they are learning. In spite of these questions—or perhaps because of them—learning analytics will see increasing adoption over the coming years.

Integrated Planning and Advising Services (IPAS)

Learning analytics can be seen as a part of the larger IPAS suite of student success services. According to the 2014 ECAR IPAS benchmarking study, these services seek to realize a comprehensive vision of a technology-enabled and integrated digital environment that provides students, advisors, and faculty with the following capabilities:

- Education planning (identifying the degree and the best path to its achievement)
- Progress tracking (asking whether the learner is on course toward degree completion)
- Advising and counseling (offering services such as mentoring and tutoring)
- Early-alert systems (initiating proactive intervention with at-risk students)

The top drivers for investing in an IPAS system are “the strategic priority of student success and the desire to reorient the institution from an enrollment to a completion culture.”²⁵

At the technology level, IPAS requires a fluid exchange of data between major applications such as the student information system (SIS) and the LMS. At the level of institutional culture, IPAS requires a viable cross-institutional partnership between the IT organization and other campus offices. The key stakeholder groups are faculty (who often have workload concerns) and, of course, students.

The IPAS trajectory shows growing adoption. In light of this momentum, it is likely to be a key and increasingly ubiquitous academic technology in the future. As noted in the ECAR study: “IPAS is coming to a student success effort near you. Our study-group institutions overwhelmingly said it is important to their efforts and that they plan aggressive adoption and investment.”²⁶

Conclusion: Swirl

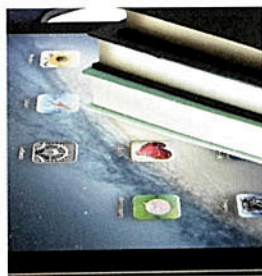
“We shape our tools and afterwards our tools shape us.”

—Marshall McLuhan

In higher education, *student swirl* refers to the practice of students formulating a custom, multi-institutional pathway to a degree. This is not a recent term: it appears to have been coined in 1990 by administrators at Maricopa Community College. But the practice is gaining momentum.²⁷

Student swirl is essentially a disaggregation/reaggregation cycle. Traditionally, the learning process and the degree conferral were aggregated into a single institution. The hop from a two-year institution to a four-year institution was the nearest thing to student swirl. Today, however, the aggregation of the learning process and the degree conferral has broken apart. Students now have more options. In short, the path to the degree is no longer linear or uniform in the traditional sense, nor does it need to be. In addition, the tempo of progress toward academic goals can accelerate or decelerate, depending on the requirements of the learner. Indeed, there are already indications that shifts in pacing have

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"arrived"; the NYU School of Medicine, for example, now offers an accelerated track to the MD degree.²⁸ Schools are also exploring badging and micro-credentials as ways to mark progress toward an academic goal, especially in the domain of competency-based education.²⁹ Obviously, we need to have discussions and debates about the quality of these new, swirled academic pathways, but the options have emerged and are being explored.

Digital technology in postsecondary education is undergoing swirl as well. Consider some of the key trends:

- The evolution or morphing of the campus IT organization, in its role as the provider of the IT environment and also with respect to its role in teaching and learning
- The increased independence of instructors and students, using their

own tools to form their connections, resulting in custom pathways to achieve learning goals

- The trend away from large central applications, run on campus servers, in favor of confederations of apps, many of which run in the cloud
- The growing importance of interoperability and interface standards
- The increase in multiple mobile device ownership
- The capacity of data analytics to profile custom portraits of learners and to make predictions and suggestions based on those portraits

In each case, there is a similar pattern: an individualization or fragmentation, together with a reassembly of the micro-units into new, custom configurations. This swirl in postsecondary educational technology is perhaps the most important trajectory of all. We have entered

into a period of both *dislocation*, when the known and familiar begin to disappear, and *relocation*, when we invent new methods, techniques, and configurations. But perhaps what characterizes our current situation best is the rapid tempo of these swirl processes—a tempo that shows no sign of abating.

It is a time that is both stressful and energizing, with both loss and new opportunity. Our task as educators is to carefully sift through these new options, being wary not only of clinging to the past but also of embracing digital snake oil. The fundamental challenges to us are to not look into the future "through a rear-view mirror" and to not have our "tools shape us." Change in higher education is inexorable, as evidenced by these six trajectories for digital technology. The only way forward to a digital learning environment is through thoughtful participation in the swirl. ■