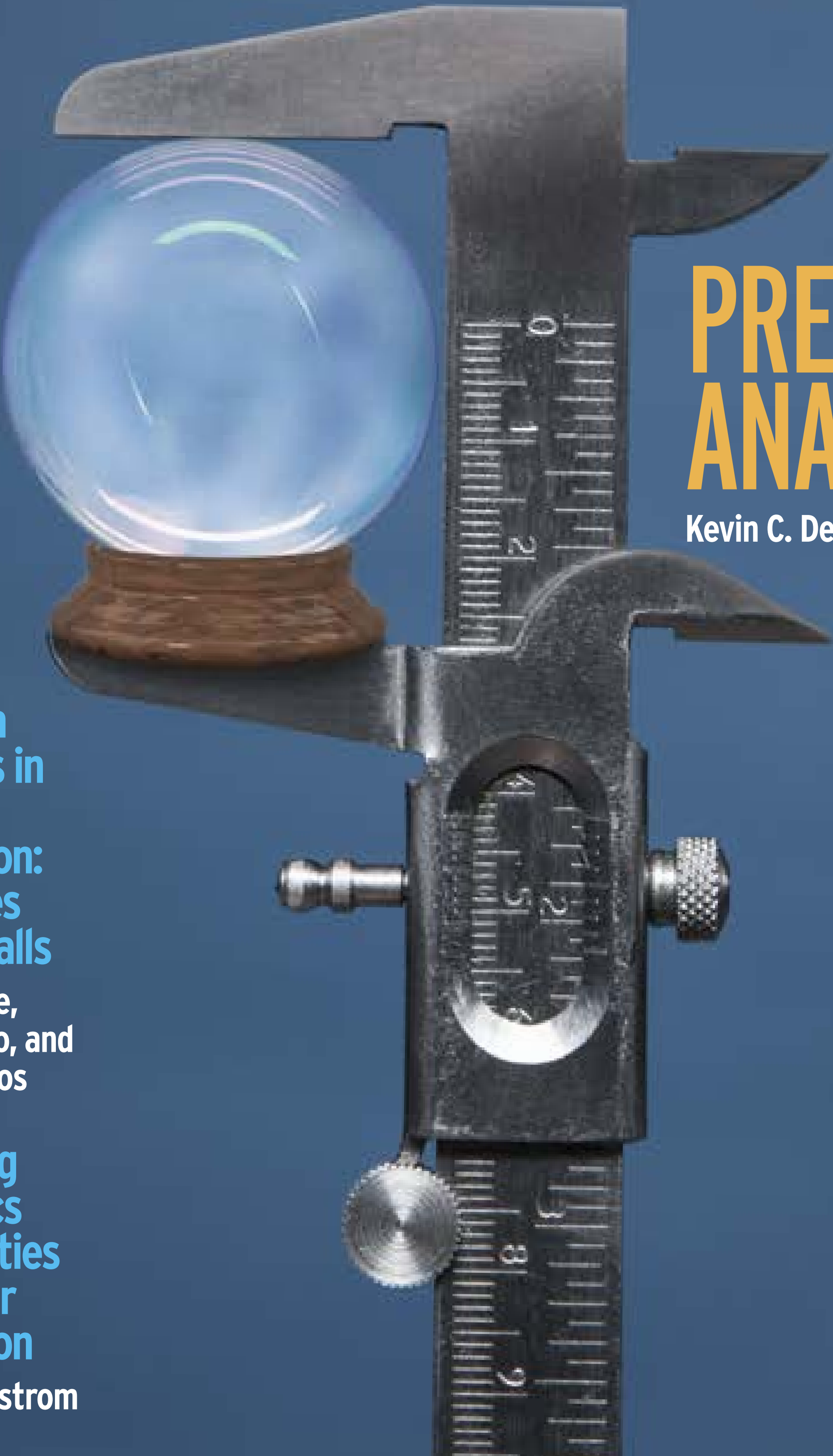
Why IT Matters to Higher Education

EDUCAUSE review

SEPTEMBER/OCTOBER 2016



PREDICTIVE ANALYTICS

Kevin C. Desouza and Kendra L. Smith

Big Data Analysis in Higher Education: Promises and Pitfalls

Chris Dede, Andrew Ho, and Piotr Mitros

Maturing Analytics Capabilities in Higher Education

Eden Dahlstrom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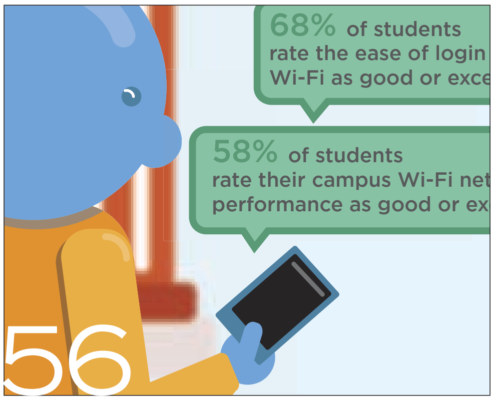
FEATURES



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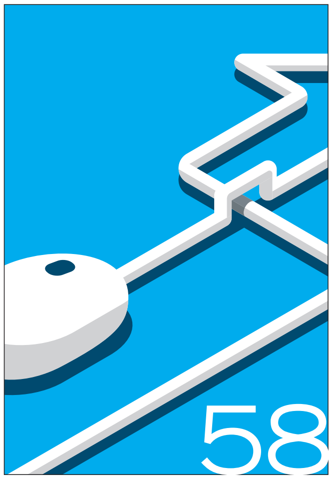

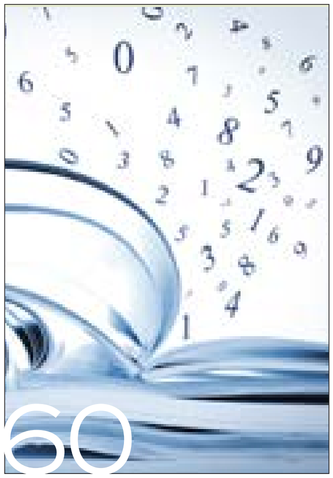

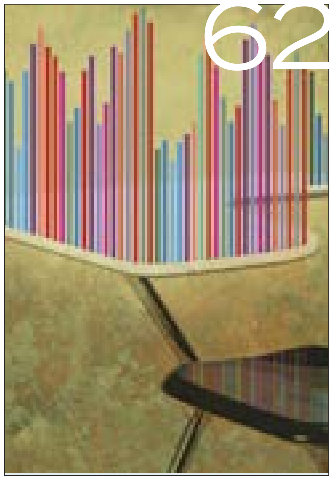

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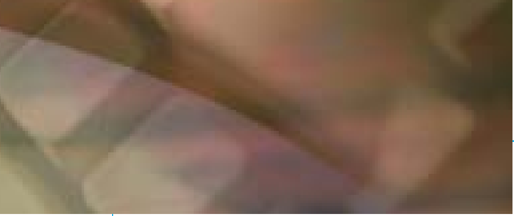

By JOHN O'BRIEN

The Unpredictability of Predictive Analytics 2.0

If I were into *scrying* (the art of predicting the future by gazing into a crystal ball), I would prophesy that *EDUCAUSE Review* readers will have two equal and opposite reactions on seeing an issue devoted to predictive analytics. The first reaction might be: "Are we still talking about how to use predictive analytics?" And the second reaction might be: "I wonder what predictive analytics we are using on our campus." We are all accustomed to tracking technologies that are emerging or that may seem to be more hype than substance, but what do we make of technologies like analytics? Here is a combination of tools and practices whose fundamental value is rarely questioned but that have not achieved the traction we might have expected by now. This issue of *EDUCAUSE Review* is a timely consideration of the state of predictive (and other) analytics across higher education: How are these tools and practices being used, how can they be better used, and how can institutions understand their own progress?

First, in "Predictive Analytics: Nudging, Shoving, and Smacking Behaviors in Higher Education," Kevin C. Desouza and Kendra L. Smith explore the use of predictive analytics in "nudge theory"—the concept that nudging individuals into making better decisions can be the key to improving institutional effectiveness and student success outcomes, high priorities both locally and nationally. The authors imagine the value of not just gathering data of all kinds but also bringing together and analyzing nonacademic behaviors such as a student's meal-consumption and gym-attendance patterns. We may know that a student is in trouble sooner if we are paying attention to when he or she starts eating less/more or exercising less/more. Proactively, predictive analytics points the way to harmless and noncoercive nudges to help a student be positioned for success.

How are the tools of predictive analytics being used, how can they be better used, and how can institutions understand their progress with analytics?

However, Desouza and Smith point out that the deployment of predictive analytics is hardly straightforward. After all, without careful attention, noncoercive nudging can become "shoving" or "smacking"—efforts that are "more coercive, restrictive, or punitive" in order to change student behavior and outcomes. Nudging, shoving, and smacking can limit student privacy in the interest of developing interventions, an especially unfortunate outcome if the line is crossed because a correlation is considered causation. For example, it may be that strong academic students eat three meals a day, so perhaps we should charge students more for their meal plan if they eat only two. Or because academically strong students tend to go to the gym, we should shove or smack underperforming students into adding a regular gym routine into their already challenging schedules.

As Desouza and Smith explore potential cautionary concerns, they go even deeper, asking a fundamental question related to what they call "automation of the academic enterprise": Who gets to decide which interventions should be used for which students? Although algorithms are the "secret sauce" of predictive analytics and automation, "ethical issues come into play." Desouza and Smith note: "Algorithms are designed by humans and can be programmed to capture biases or make judgments within those biases, either on purpose or accidentally." Some of these thoughts are reflected in a recent *New York Times* op-ed, where Kate Crawford notes that artificial intelligence and algorithms reflect the values of their creators.[1] A very real threat is the subtle embedding of human bias in the automation code that we will increasingly rely on, in ways most of us can't yet even imagine. This is a "data problem," Crawford concludes. "Predictive programs are only as good as the data they are trained on, and that data has a complex history."

The source of data is a focus for Chris Dede, Andrew Ho, and Piotr Mitros as well. As they explain in "Big Data Analysis in Higher Education: Promises and Pitfalls," many of the pitfalls for big data analysis stem from failing to ask the question "Where does data come from?" Conventional digital assessments

(continued on page 6)

(continued from page 4)

also fail to capture the extent to which students have mastered complex skills. As a result, although big data is increasingly being used for decision making in higher education, the authors note that "practical applications in higher education *instruction* remain rare."

Dede, Ho, and Mitros emphasize how MOOCs (massively open online courses) provide a promising opportunity for data-intensive research and analysis in higher education instruction: "MOOCs illustrate the many types of big data that can be collected in learning environments. Large amounts of data can be gathered not only across many learners (broad between-learner data) but also about individual learner experiences (deep within-learner data)." Not surprisingly, all of this data collection leads back to predictive analytics: "The most common questions being asked of digital learning data involve prediction." In one sentence, the authors ground this work in a crucial, student-centered context: "The criterion for prediction is not accuracy, as measured by the distance between predictions and outcomes. Instead, the criterion is impact, as measured by the distance between student learning with the predictive algorithm in place and student learning had the algorithm not been in place."

We have data, and we have tools for analyzing that data, and we have reasons for using that analysis. To what extent are our institutions collecting the data, adopting the tools, and deploying the analytics? In "Moving the Red Queen Forward: Maturing Analytics Capability in Higher Education," Eden Dahlstrom illuminates a confounding picture in which interest in analytics is high but deployment lags. As she explains, new tools from EDUCAUSE may help shed some light. We developed our first stand-alone maturity index in 2012, and we are currently beta-testing eight maturity indices and five deployment indices. The strength of these indices is that they offer institutions the chance to answer a few dozen questions and to see, at a glance, the maturity of a specific initiative (i.e., the maturity index) or the stage reached by a given technology deployment (i.e., the deployment index). Institutions can then compare their results with those of other institutions or groups of institutions. In other words, using these new benchmarking tools, institutions can "pop the hood" and see exactly what is going on in eight dynamic topic areas, including analytics. They can also track numerous dimensions—32 factors in the case of analytics, for example.

Not all of what makes an analytics initiative "mature" consists of predictable technology issues such as technology infrastructure and data efficacy. For example, the analytics maturity index also considers the resources and investment dedicated to analytics, the decision-making culture on campus, data-related policy sophistication, and collaboration between IT and IR professionals. It is a *complete* picture of the complex array of factors that make such initiatives successful. Unfortunately, the dimension of investment and resources remains the least advanced. Dahlstrom notes: "Despite widespread interest, analytics is still not regarded as a major institutional priority at most institutions." And in the world of analytics investment and interest, learning analytics lags even the lagging institutional analytics—as Dede, Ho, and Mitros also observe. The EDUCAUSE deployment index for analytics shows most of the deployments happening at the experimental level, "with fewer than 21% of institutions reporting institution-wide deployment." When it comes to longer-term predictions, EDUCAUSE strategic technology research finds that five years from now, big data use by colleges and universities will still be emergent.

It may well be that all three of the conversations about analytics in this issue of *EDUCAUSE Review* are, well, *predictable* for a technology in version 2.0 or higher. As we settle into the role that analytics can, will, or should play on our campuses when fully deployed and fully matured, we naturally move from expressions of hype to more realistic, balanced, and cautionary conversations. Tackling the quandary of why higher education hasn't seen the traction that we expected may not be a separate venture from tackling the tactical, practical, and ethical concerns. Both ventures are necessary to fully realize the promise—dare I say, the predictability?—of predictive analytics in higher education.

Note

1. Kate Crawford, "Artificial Intelligence's White Guy Problem," *New York Times*, June 25, 2016.

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Institutional Analytics Is Hard Work: A Five-Year Journey

Higher education leaders have been faced with competing and conflicting challenges for years. Increasing competition for students, a continuous decline in funding, and greater accountability amid rising operational challenges stand out as consistent themes. This confluence has created a sense of urgency to leverage data to inform decision making like never before. The number of colleges and universities implementing business intelligence and analytics initiatives has been on the rise. Simultaneously, an increasing number of companies have introduced or expanded their technology and services portfolios, offering analytics "solutions."

Yet as Bridget Burns, executive director of the University Innovation Alliance, observed in January 2016: "Despite the hype, the [data-driven decision-making] field remains nascent, the implications uncertain."[1] Burns's perspective on the infancy of the field of analytics can be attributed to one simple truth: *institutional analytics is hard work.*

An important theme, often absent from the dialogue, is an acknowledgment of the heavy lifting required to leverage analytics as a strategic enabler to transform an institution. There is no "easy button" for improving the financial, educational, and operational outcomes across an institutional enterprise. Doing so requires a combined commitment of technology, talent, and time to help high-performing colleges and universities leverage analytics not only for one-time insights but also for ongoing performance management and improvement guided by evidence-based decision making.

A growing number of senior administrators and presidents believe that analytics will play a key role in the success of their institutions. Even though the work required to yield significant results in institutional analytics is hard and the journey long, the cost of doing nothing is no longer an option for most higher education institutions.

Lessons from a Five-Year Journey to Advanced Institutional Analytics

In 2011, the University of Maryland University College (UMUC) had reached an inflection point in its use of data. The university had a data warehouse in place primarily to support operational reporting needs across the institution. The decision was made to bring in private-sector analytics expertise to help get more value from the data and to introduce the competency of business analytics and financial planning to the university setting. Our focus was on increasing the amount of time spent on high-value analysis while introducing greater efficiencies in preexisting operational reporting. We thus began what would be a multiyear journey to effectively leverage data to inform decisions, impact business outcomes, drive policy, and guide the university along a continued path of stability and growth. During this time, we experienced an organizational and cultural transformation into a state of advanced, institution-wide analytics.

We learned four fundamental lessons from this experience—lessons that are relevant for any institution looking to jumpstart or accelerate its path to advanced analytics.

Lesson 1. Centralize: Prioritize Data Collection, Quality, and Transparency

The Challenge: Decentralized institutional data introduces a whole host of challenges, from the absence of common data definitions to the inability to conduct cross-functional data analysis. The implications of these challenges, highlighted in KPMG's 2015–2016 Higher Education Industry Outlook Survey,[2] include (1) limited strategic and operational use of data, and (2) absence of best practices to effectively use data residing across different functions.

Best Practice: Analytics can and should be centralized, providing a single point of entry for all stakeholders to access insights across the university. To achieve this, we designated a leader who had the authority to refine and broaden scope, embrace transparency and communicate objectively, and institute best practices to use data across different functions.

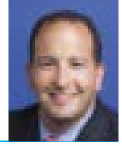
Results: Focusing on integrating and validating institutional data in a central location created a single point of truth at the university.

Lesson 2. Optimize: Focus on Building Data Models, Not Reports

The Challenge: When the majority of time is spent on operational reporting, data stewards have little time to dedicate to higher-value analyses. Time-consuming and manual processes for reporting introduce both inefficiencies in daily operations and implications for the strategic use of data to monitor and improve overall institutional health.

Best Practice: UMUC "doubled down" on its spend on analytics through a combination of investments in high-performance cloud computing, data integration and modeling, and an intuitive data-visualization platform. The models accelerated the ability to prototype and quickly answer ad hoc requests.

Results: Data that was once considered complex and inaccessible could now be consumed, understood, and analyzed by both power and casual users across the university. This invest-

ment increased access to actionable information for a broader set of stakeholders, introduced efficiencies in reporting, and created opportunities for sophisticated, high-value analysis.

Lesson 3. Communicate: Invest in Data Analysis and Storytelling Expertise

The Challenge: Although providing access to actionable information is a critical step, there are often varying degrees of resources and fluency across university units in data analysis and storytelling. As noted in the KPMG survey, only 29 percent of respondents "have sufficient access to data and resources to analyze and use it for strategic and operating decisions."[3] Thus, many departments are still not able to uncover insights and translate them into actions or business outcomes on their own. As Brent Dykes has noted: "Unless we can improve the communication of these insights we will also see a poorer insight-to-value conversion rate. If an insight isn't understood and isn't compelling, no one will act on it and *no change will occur*."[4]

Best Practice: We overcame this challenge by investing in building up data science and storytelling expertise within the Office of Analytics[5] to communicate data insights across the university. Using the centralized data platform, staff in this office started by identifying core questions that the university needed to answer. The team quickly realized the need to be proactive and engage the university community in a significantly different way in order to facilitate meaningful conversations. Evolving into an internal professional services arm, the analytics team provided ongoing data analysis, visualization, and storytelling services to internal constituents. The team's job was to take the complexity out of the data and present it in an easily understood and consumable fashion.

Results: The combination of platform and services introduced significant efficiencies in reporting while also increasing opportunities to facilitate meaningful and strategic conversations across the institution. The Office of Analytics became an objective, independent actor, serving a broad set of stakeholders across the university.

Lesson 4. Connect: Implement "Educational Intelligence" to Address Institution-Wide Challenges

The Challenge: Although an increase in access to actionable data and sophisticated high-value analysis contributes to progress on the path to institutional analytics, silos persist. Departments evolve at varying paces, and institutional inertia is still one of the greatest hurdles. How does an institution reach a point where data is critical both *within and across* traditional departments?

Best Practice: The unified data layer at UMUC allowed the Office of Analytics to demonstrate the potential of cross-functional analysis to stakeholders and implement "educational intelligence"[6] across the institution. By combining data sets, the Office of Analytics was able to answer questions such as the following:

- How can we segment students into subpopulations to better serve them?
- What variables are predictive of enrollment growth or decline?
- What impact do financial aid changes have on enrollment and bad debt?
- Are there significant opportunities to improve student persistence?
- How does student activity in the classroom correlate with student success?
- Which degree programs are driving demand, degree production, and revenue?

Results: Through increasing visibility into the connections across units, the university has reached a state of advanced institutional analytics. As data drives decisions across the university, stakeholders continue to see positive results—from improving persistence and retention rates to increasing enrollments while reducing expenditures on recruitment.

The Path Forward

UMUC has made great progress on the path to institutional analytics. In 2015, the University System of Maryland Board of Regents approved a plan to spin off the UMUC Office of Analytics into a new company, HelioCampus.[7] Yet the journey continues, and these lessons remain core to the university mission. Regardless of type of institution or its stage in the journey, these lessons represent fundamental pillars for providing leaders with greater visibility into the connections between student outcomes, tuition revenue, and expenses—and with guidance on how to take action. ■

Notes

1. Bridget Burns, "Big Data's Coming of Age in Higher Education," *Forbes*, January 29, 2016.
2. Milford McGuirt, David Gagnon, and Rosemary Meyer, "Embracing Innovation: 2015–2016 Higher Education Industry Outlook Survey" (KPMG).
3. Ibid., 12.
4. Brent Dykes, "Data Storytelling: The Essential Data Science Skill Everyone Needs," *Forbes*, March 31, 2016.
5. The Office of Analytics was led by Darren Catalano.
6. Eduventures introduced the term *educational intelligence* in 2015 as an approach to "leveraging data at multiple points across the student lifecycle to make intelligent decisions to positively impact student outcomes." See Max Woolf, "Educational Intelligence Should Be in Your Vocabulary," *Wake-Up Call* (Eduventures blog), September 8, 2015.
7. Darren Catalano, who had been brought in from the private sector in 2011, is CEO of the new company, leading a growing team of data scientists, engineers, and analysts dedicated to furthering institutional analytics at UMUC and at other colleges and universities nationwide.

Javier Miyares (president-office@umuc.edu) is President of University of Maryland University College (UMUC). **Darren Catalano** (darren.catatano@heliocampus.com) is CEO of HelioCampus and former Vice President of Analytics, University of Maryland University College (UMUC).

Predictive Analytics:

Nudging, Shoving, and Smacking Behaviors in Higher Education

By Kevin C. Desouza and Kendra L. Smith

Like most other enterprises, academia is on the quest to leverage data to improve outputs and outcomes. At their core, academic enterprises are focused on advancing knowledge in society and transforming society through their outputs (e.g., the students they produce, the research they generate, and the interactions they cultivate with communities both local and global). Data management and analytics can significantly increase the odds that a higher education institution will deliver on its goals in an optimal manner.

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Today, colleges and universities are collecting data on just about all facets of the academic ecosystem. For instance, data is being collected on students—not only regarding how they perform on a given course but regarding all aspects of student life: housing, finance, social activities (e.g., participation in student organizations, attendance at sporting events, gym membership). In addition, data is being collected on the research performance/productivity of faculty: the number of grant applications submitted, research awards received, publications and patents produced. Academic enterprises also collect an enormous amount of data on their donors and alumni. And finally, data is generated from institutional general operations (e.g., data on buildings, energy systems, human resources). Historically, colleges and universities have used this data for simple transaction-processing purposes such as invoicing, resource-allocation decisions, and budgeting. However, they are becoming much more sophisticated in their usage of data through *predictive analytics*.

Interest in using data more creatively (some might say, more innovatively) as a way to become more precise in how interventions are devised to improve outputs and outcomes is at an all-time high. And rightly so: precision allows academic enterprises to get near real-time situational awareness on agents (e.g., students, faculty, researcher teams) and objects (e.g., buildings, systems) that are of interest to them. Data collected can also be contextualized both temporally (i.e., against historic performance and future trends) and spatially (i.e., across units and enterprises). Precision is executed through predictive analytics in the mining of large swaths of data—or big data—to spot trends and probabilities and thus predict future behaviors. With predictive analytics, colleges and universities are able to "nudge" individuals (predominantly students) toward making better decisions and exercising rational behavior to enhance their probabilities of success.

Nudging

The concept behind nudging and nudge theory centers on prompting individuals to modify their behavior in a predictable way (usually to make wiser decisions) without coercing them, forbidding actions, or changing consequences. Nudging has been around for some time but became popularized with the 2008 book *Nudge: Improving Decisions about Health, Wealth, and Happiness*, by Richard H. Thaler and Cass R. Sunstein. The book extolled the potential of nudging to increase the effectiveness of government by understanding the psychological or neurological biases that cause people to make choices that are not in their best interest (e.g., driving without a seatbelt, smoking, doing drugs, not studying, cheating on taxes). Later researchers followed up on this work by providing an organizational framework that categorized nudging along four dimensions (see table 1).[1]

Research has proven that nudging is effective in steering individuals toward better decisions through *choice architecture:* the presentation of choices in different ways.[2] Choice architecture doesn't look for individuals to act more rationally; instead, it seeks to create environments that accord with rational decision-making. We frequently see (without noticing) nudging in our daily lives: electronic highway signs that say "Drive Drunk and Get Nailed" to prevent drunk driving; modified food displays that bring healthier food to eye level and make junk food harder to reach; organ donations that are an opt-out policy on drivers licenses instead of an opt-in policy.

Research has proven that nudging is effective in steering individuals toward better decisions through *choice architecture.*

In academia, data collected from and about students can signal how they are performing at any given time, which can be integrated with other course performance data (i.e., the courses that students are enrolled in at the same time) to see whether students either are not performing well in just one class or are

TABLE 1. FOUR DIMENSIONS OF NUDGING

Dimension	Description
Boosting Self-Control vs. Activating a Desired Behavior	Assisting in follow-through with decisions vs. influencing a decision that an individual is indifferent or inattentive to
Externally Imposed vs. Self-Imposed	Acts that are deemed important and voluntarily adopted vs. acts not requiring people to voluntarily seek them out
Mindful vs. Mindless	Guiding toward a more controlled state that helps people with follow-through on acts they would like to accomplish but have trouble enacting vs. using emotion, framing, or anchoring to sway the decisions that people make
Encourage vs. Discourage	Facilitating a particular behavior vs. hindering or preventing behavior that is believed to be undesirable


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having a challenging time across all (or a majority) of the courses in which they are enrolled. This information can then be shared with faculty and advisors. It can also be contextualized further if linked to other data sources such as meal habits, which can show that a student has gone from eating three meals a day on campus to just one, or number of gym visits, which may show a change in activity. In the purest sense, we could have multiple views of a student (this is not that difficult to do, since most institutions link these activities to the ID cards that students carry) with all data integrated, thereby giving us a more holistic view of the individual. Now imagine this at scale, and we have the ability to see data more comprehensively across the entire student population and to perform comparisons across all groups (e.g., freshmen versus seniors, engineering students versus business students).

We then have the possibility to leverage experimentation to test the effects of various types of interventions. What happens if we have a different instructor in one class versus another? Does that improve the odds of interest in a given major? What happens if we intervene early on to assist students struggling with writing or math courses? Does that increase their chance for success in the long run? We might even be able to ask questions such as how might we identify early signs of poor well-being (e.g., a student who has never used the gym facilities or one who, based on data from his/her meal plan, is not getting the right diet). Yes, this last example is a bit unusual, but we will be able to ask these types of questions because the data is there. For each of the above questions, we could try several interventions to see what works and what does not work. We can collect data, analyze it, identify significant effects, and then implement evidence-based nudging strategies.

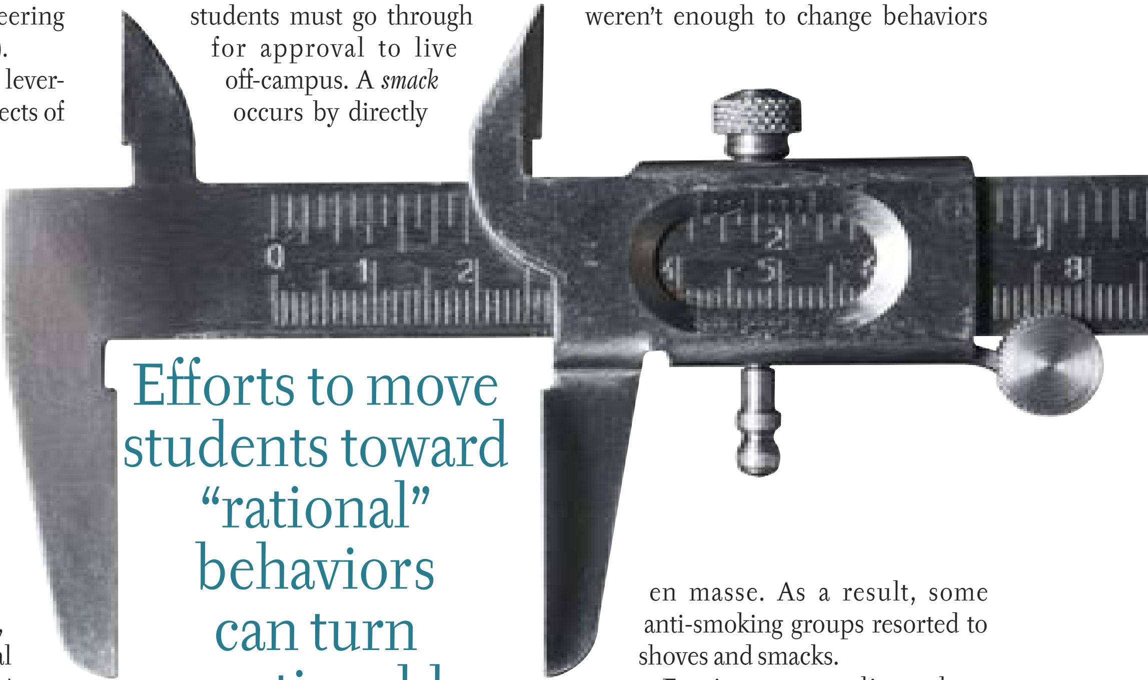
But things are seldom this simple in life, and with academic institutions, things are rarely ever this simple. With nudging, several additional issues need to be considered.

Shoving and Smacking

The business and science of changing behaviors has mixed reviews. To be clear, we should note that nudging, by itself, is generally harmless and noncoercive. However, efforts to move students toward "rational" behaviors—efforts that are often seen as a nudge—can turn questionable when they become more coercive, restrictive, or punitive. At this point, the nudge becomes a shove or a smack. A *shove* (a much more deliberate nudge) occurs by making certain desires tougher to achieve, such as by increasing taxes on cigarettes or necessitating numerous procedures that students must go through for approval to live off-campus. A *smack* occurs by directly restricting activities, such as banning smoking in public places or living off-campus.

Consider the public health issue of smoking. More than fifty years after the U.S. Surgeon General's landmark report on the health risks of smoking cigarettes, the goal of reducing the number of people who smoke is still a challenge in the United States and in most other countries as well. Up until about the 1990s, smokers could smoke just about anywhere: on airplanes, in office buildings, in restaurants, in colleges and universities, and in bathrooms. As public health officials intensified their efforts to decrease smoking, they began nudging the public, using nudges such as financial incentives or commercials showing the severe effects of smoking. Though effective in some groups, these nudges weren't enough to change behaviors en masse. As a result, some anti-smoking groups resorted to shoves and smacks.

For instance, policymakers began shoving smokers into new behaviors by implementing higher state excise taxes on cigarettes. With financial disincentives, this practice moves away from nudging and into a paternalistic and coercive type of behavior modification. But according to the Campaign for Tobacco-Free Kids, the shoving had an effect: increasing excise taxes has helped reduce smoking, especially among



Efforts to move students toward "rational" behaviors can turn questionable when they become more coercive, restrictive, or punitive.

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The Extron SMP 351 Streaming Media Processor serves the role of a "capture agent" in an Entwine EMP system. It combines a presentation source and camera video of the instructor with a background image into flexible layouts, which deliver the live presentation experience. Integrated together, the SMP 351 and Entwine EMP provide a complete end-to-end solution for automating the recording workflow, from scheduling to publishing.

Entwine EMP - Enterprise Media Platform

Entwine Enterprise Media Platform for Lecture Capture is Extron's content management solution for scheduling, processing, managing, and distributing media files. It interfaces with standard network directory services to integrate users and access rights into the system. Powerful video search options and user-defined workflow automation streamlines content management.

children. For every 10 percent increase in the price of cigarettes, overall cigarette consumption declines 3–5 percent and consumption by kids declines 6–7 percent.[3] Policymakers then went a step further and began to smack smokers, through the restriction of smoking in public places. The actual elimination of choice is coercive, even if effective.

The differences between nudging, shoving, and smacking are extremely important in higher education as colleges and universities make their foray into the realm of predictive analytics and automation. For a number of reasons, the effect of nudging on students and academics can be the opposite of what is intended. The first, and perhaps most obvious, reason is the question of who decides what an "appropriate" intervention is. For small issues, such as students who are underperforming in class, there might be a simple solution, but for more complex problems, there aren't always simple descriptions of the problems or simple answers. In a nonacademic example, Saurabh Bhargava and George Loewenstein discuss the complexity of deciding where to nudge regarding the problem of obesity.[4] Although obesity results from the continued intake of excessive calories, the causes of this problem are rooted in issues related to food production, policy, culture, and socioeconomic factors. Food production innovations enable faster and cheaper food generation, which makes unhealthy food much cheaper to purchase (and thus appealing to low-income individuals) and enables policy decisions such as the subsidization of corn (and corn syrup). Also exacerbating the obesity issue is the cultural phenomenon of "super-sized" portions of meals and the increased physical inactivity due to video games, the Internet, and television. Given all of these contributing factors, nudging healthy behaviors can be done by suggesting the intake of fewer calories, by reducing access to unhealthy foods, and by encouraging more physical activity and smaller portion sizes. But who is to decide which of these nudges is appropriate?

A second reason that nudging can have the opposite effect on students and academics involves balancing individuals' privacy and freedom versus knowing what is "best" for them. Students today have a much different notion of privacy than their parents had, but they could nevertheless object to their information being used in a way that could be construed as damaging to them. The choices that students make along their pathway to academic success are their own. What happens when nudging has been used and an individual still chooses not to perform? How do we deal with outliers at the low end of the spectrum when it comes to various distributions associated with performance and behavior? We might simply say that the nudge didn't work, or we might reevaluate the nudge, but resulting actions could have quite damaging effects, such as students being placed on probation or even being asked to leave the college or university. In addition, acting on data from just one instance or just one case is going to be problematic. We need to see trends across groups and make sure our results are significant. With predictive analytics, we are trying to personalize the delivery of services and content; we thus need to consider the tradeoffs between how much generalizable knowledge we want to generate versus the specificity of knowledge that matters to a single individual or a small community or group.

Third, nudging thrives on information that creates profiles full of probabilities and trends about behaviors, but what if these trends are not indicative of other issues? Most academic enterprises pride themselves on attracting a diverse student body across dimensions of socioeconomic status, race, religion, orientation, sexuality, veteran status, and other subcultures, many of which are not captured in data. Nudging students for "rational" behaviors that may not be rational to them is an error and can be considered a misuse of information and authority. This can be particularly damning when we consider the use of automation in the nudging process.

Automation of the Academic Enterprise

The combination of automation and nudges is alluring to higher education institutions because it requires minimal human intervention. This means that there are greater possibilities for more interventions and nudges, which are likely to be much more cost- and time-effective. In retail and merchandising, for example, automated nudges alert sellers to opportunities such as adding products to avoid going out of stock and sharpening prices to increase competitiveness. In his 2015 letter to shareholders, Amazon founder and CEO Jeff Bezos noted that the company sends more than 70 million of these nudges weekly.[5]

> The combination of automation and nudges is alluring to higher education institutions because it requires minimal human intervention.

The "secret sauce" of predictive analytics and automation is sophisticated algorithms. Algorithms are rules that order the sequence of operations, thus driving the technological innovations we know and love today. Algorithms power our mobile phone operating systems so that we can interact with our devices and get the same experience each time, they help make matches on dating apps, they assist with identity theft and fraud detection, and they allow us to get the most relevant information when we search Google.

Algorithms are what make data so valuable and useable. With automation, we can speed up the process and turn insights into action. Thus, as we collect more data, we will know precisely what works and what does not work under varying conditions. This is good news. The even better news is that this will lead to a rethinking of the academic enterprise and its educational focus and mission.

For instance, serious games enable students to learn at their own pace and to process material better than they may be able to in a classroom setting. Students gain from personalized feedback and the engagement of a gaming environment to learn concepts and to maneuver complexities associated with those concepts as they advance through the various levels of the game. In addition, the provision of rewards (e.g., badges earned) gives students not only a sense of achievement but also the ability to compare their performance and ranking with that of their peers. Education technologists will soon look at how much automation can be brought into the course delivery of what might be considered standard and structured (and even semi-structured and loosely or unstructured) content. The development of automation (artificial intelligence redefined) not only will impact how we drive our cars (the rise of autonomous vehicles) but also will shape how we think about higher education content delivery. Simply put, we can build algorithms that learn from interactions with subjects as they maneuver their learning environments. These algorithms can direct the learning sequence and also motivate students to perform at higher rates, engage groups in activity, and advance learners' knowledge. Many of the frameworks and platforms on which electronic games are based are extensible to the education space.

Will we really need instructors to teach college and university students basic statistics? Can't students get the content they need through a combination of online videos, pre-canned online lectures, and a series of game-based content progression and examination? The answer to this question will depend on several factors, early on. We believe that for most students the answer will be "yes." The benefit is that these students will not have to sit through 15 weeks of classes to receive content they may be able to learn in 8 weeks or even 1 week. The bad news is what will happen to those students who do *not* fare well on these platforms and who need human instruction. Do we charge the second group of students different fees, just as banks and airlines charge fees if a customer wants a human-driven transaction versus an automated one? Will we offer two categories of degrees—those that are earned through autonomous learning environments and those that are traditional? Early on, hybrid-learning environments are likely to be embedded in traditional degrees. Over time, however, the sophistication of automation will create new business models for higher education. In fact, we have been contemplating these scenarios for a while, and for us, the bottom line is that the future does not look good for traditional academic institutions. The days when an institution's brand or a particular degree (e.g., MBA) generates differential revenues just because courses are delivered in person, through traditional modes of instruction, will be numbered. Institutions that are late adopters of the digital education innovation space—not simply repurposing traditional content and delivering it online but, rather, leveraging the digital platform and technologies to create immersive, anytime, learner-focused, and knowledge-intensive experiences—will be left in the dust.

Assuming the academic enterprise gets analytics right and learns how to conduct experiments ethically and responsibly, higher education institutions will be able to learn quite a bit to help transform the educational experience of students. Although we have focused on educational outcomes in this article, the same can be said of all other facets of running an academic enterprise (e.g., managing research and development efforts from collaborations to seed investments). Automation goes beyond students and the classroom and extends to faculty. For instance, colleges and universities have nudged faculty to adopt education technologies by directing them to make their courses more amenable to technology-driven delivery and to develop course content that is open or is designed to be replicated for mass consumption. Institutions do so by incentivizing faculty efforts.

Right now, these processes are not incredibly automated, but they could be, in more nuanced ways, as academic

enterprises consider how to break apart the education process as we know it today and make it more efficient and profitable. Academia is ripe for disruption, given the intensified focus on using technologies to transform the process of how students learn and consume content and given the interest in automation of experiences through gaming and artificial intelligence. Ethical issues come into play, however. Some researchers argue that algorithms are more ethical than humans because the former have limited biases, but this is not 100 percent true. Algorithms are designed by humans and can be programmed to capture biases or make judgments within those biases, either on purpose or accidently. This can create serious implications of misdirected nudges, shoves, and smacks.

Flirting with Disaster?

Nudging opens up risks on opposite extremes linked to data and how data is used. The first risk is the danger of ignoring variances in data. Valuable data elements that may impact our understanding of the underlying phenomenon and the design of the intervention—elements such as diverse information that is difficult to capture—can be overlooked. Second, on the other extreme, academia may be flirting with discrimination by using group attributes to generalize patterns across individuals who might have features connecting them to one or more categories. Algorithms pick out data points that make up a small (e.g., high school GPA, major, hometown, residence, financial aid status) or large (e.g., race, socioeconomic status, marital status, gender) portion of an individual's experience, but should these data points become a factor in the types of nudges used?

One way to prevent this is by having a theoretical base for an intervention. The temptation with big data analytics is to see correlations as causations. Big data often spews out spurious correlations that, if not examined carefully, can be acted on with negative results. To get an underlying causation, we need to conduct systematic randomized controlled trials, which are not going to be easy in academia. Can we justify giving special resources to one group and not to another in order to test a causation? Other issues are also critical, such as getting informed consent and letting participants know about the experiment.

Further, understanding how to share performance data so that individuals can make their own decisions and choices is imperative. Consider the case of utility companies that have experimented with giving individuals data regarding how their consumption compares with that of their neighbors who have similar properties. These experiments have shown that individuals are more likely to consider modifying their consumption behavior when they see how neighbors are consuming a resource and that this data is more influential than other forms of data shared, such as how much money they could save on their utility bill through behavior modification. Similarly, in the academic space, we need to devise more performance measures that can be shared and that go beyond the traditional measure of GPA. In addition, experiments need to be conducted to see how the provision of information—that is, the frequency and the nature of the information provision—actually modifies behavior.

Another issue is the measuring of outcomes versus outputs. Academia is very good at measuring outputs: research, grades, awards. However, outcomes are harder to capture, and most colleges and universities justify their performance by relying on the arbitrary rankings conducted by third-party organizations (e.g., *U.S. News & World Report*) as a surrogate. To truly leverage analytics toward long-term measures that benefit students, we need to be able to measure outcomes and track them over time. This is not going to be easy or cheap to do. In addition, we will need to build a culture in which students are encouraged to share reliable data with their institutions after graduation. This again will require investments, along with a rethinking of how alumni associations interact with the academic enterprise.

To truly leverage analytics toward long-term measures that benefit students, we need to be able to measure outcomes and track them over time.

Conclusion

Although nudging in small doses makes a difference, nudging is no panacea for all of the complex problems found in higher education. There are few studies that evaluate the overall effectiveness of nudging in changing behaviors and sustaining impact.[6] Some studies even note the adverse effects of nudging.[7] Like anything else in life, knowing when to use nudging—and when enough is enough—can be a challenge.

The answer is not simple. Perhaps the deepest concern lies in the definition of the problem and in who decides the direction of nudges. Nudging can easily become shoving or smacking. Obviously, the intentions behind most higher education practices are pure, but with new technologies, we need to know more about the intentions and remain vigilant so that the resulting practices don't become abusive. The unintended consequences of automating, depersonalizing, and behavioral exploitation are real. We must think critically about what is most important: the means or the end.


ADVANCED SECURITY FOR ADVANCED THREATS

With the transformative nature of new capabilities, we should explore both the opportunities and the threats associated with nudging in higher education. This is especially true at a time when academic credentials beyond the high school diploma are needed to acquire entry-level jobs, when colleges and universities are experiencing retention challenges, and when funding for higher education is decreasing. Nudging, used wisely, offers a promising opportunity to redirect students' decisions and to contribute to the success of those students facing the steepest barriers. ■

Notes

The views expressed in this paper are those of the authors and do not represent official viewpoints of any organization with which they are associated.

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BIG DATA ANALYSIS IN HIGHER EDUCATION: Promises and Pitfalls

By Chris Dede, Andrew Ho, and Piotr Mitros

Technological and methodological advances have enabled an unprecedented capability for decision making based on big data. This use of big data has become well established in business, entertainment, science, technology, and engineering. Whereas big data is beginning to be utilized for decision making in higher education as well, practical applications in higher education *instruction* remain rare.

Hindering these applications are challenges unique to higher education.[1] First, the sector lacks much of the computational infrastructure, tools, and human capacity required for effective collection, cleaning, analysis, and distribution of large datasets. In addition, in collecting and analyzing student data, colleges and universities face privacy, safety, and security challenges not found in many scientific disciplines. Higher education is also concerned with long-term goals—such as employability, critical thinking, and a healthy civic life. Since it is difficult to measure these outcomes, particularly in short-term studies, those of us in higher education often rely on theoretical and substantive arguments for shorter-term proxies.

Beyond the potential to enhance student outcomes through just-in-time, diagnostic data that is formative for learning and instruction, the evolution of higher education practice overall could be substantially enhanced through data-intensive research and analysis. A worthy next step would be to improve our capacity to rapidly process and understand today's increasingly large, heterogeneous, noisy, and rich data sets.

Big Data and MOOCs

Since the definition of *big data* is still developing, we will start with our use of the term. In 2001 Doug Laney, an analyst with the META Group (now part of Gartner), described big data with a collection of "v" words, referring to (1) the increasing size of data (*volume*), (2) the increasing rate at which it is produced and analyzed (*velocity*), and (3) its increasing range of sources, formats, and representations (*variety*). To this other authors have added *veracity*—to encompass the widely differing qualities of data sources, with significant differences in the coverage, accuracy, and timeliness of data. Our discussion of the promises and pitfalls of big data analysis in higher education places a particular emphasis on veracity.[2]

In addition, our discussion focuses on MOOCs (massively open online courses) as an opportunity for data-intensive research and analysis in higher education. MOOCs illustrate the many types of big data that can be collected in learning environments. Large amounts of data can be gathered not only across many learners (broad between-learner data) but also about individual learner experiences (deep within-learner data). Data in MOOCs includes longitudinal data (dozens of courses from individual students over many years), rich social interactions (e.g., videos of group problem-solving over videoconference), and detailed data about specific activities (e.g., watching various segments of a video, individual actions in an educational game, or individual actions in problem solving). The depth of the data is determined not only by the raw amount of data on a learner but also by the availability of contextual information.[3]

MOOCs illustrate the many types of big data that can be collected in learning environments.

These types of big data in higher education potentially provide a variety of opportunities to improve student learning:

- Individualizing a student's path to content mastery, through adaptive learning or competency-based education
- Better learning as a result of faster and more in-depth diagnosis of learning needs or course trouble spots, including assessment of skills such as systems thinking, collaboration, and problem solving in the context of deep, authentic subject-area knowledge assessments
- Targeted interventions to improve student success and to reduce overall costs to students and institutions
- Using game-based environments for learning and assessment, where learning is situated in complex information and decision-making situations

The Value of Big Data in Assessing Complex Skills

Conventional assessments in higher education classrooms are infrequent and constrained, both in their design (e.g., essay prompts, multiple-choice questions) and in their feedback (which is usually delayed and sometimes subjective). Progress in educational technology can provide tools for measuring students' performance on more authentic tasks, such as engineering design problems and free-form text answers. Measuring these types of tasks can increase the relevance and the precision of the results regarding what students learn, can allow the tailoring of instruction to specific students' needs, and can give individualized feedback across a range of learning issues.

In addition, social interactions have increasingly moved from in-person to online. Big data can include detailed traces of student-to-student interactions. By integrating these and other sources of data, we may be able to measure more complex problem-solving and collaborative skills. Fulfilling this promise requires finding ways to analyze complex data from heterogeneous sources to extract such measurements, parallel to similar advances already taking place in the sciences and engineering.

Over the past two decades, this fundamental progress in educational technology has been combined with its broad-based adoption at scale.[4] Digital assessments allow more direct review of relevant, authentic performances. Previously, widely available data for large numbers of students principally came from standardized exams or standardized research instruments, such as the Force Concept Inventory in Physics. These assessments are limited to a short time window; as a result, they contain either a large number of small problems

(which ensures that the results are precise but generally fail to capture complex skills requiring more than a minute or two to demonstrate) or a small number of large problems (which lacks any precision on a per-student basis).

In contrast, many MOOCs include data from students who are completing large numbers of complex problems as part of their regular coursework. For example, 6.002x—the first edX/MITx course—used assessments that consisted entirely of relevant performance tasks. Students completed design-and-analysis problems that required answers written as equations, numbers, or circuits.[5] Since these types of questions have a near-infinite number of possible solutions, answers cannot be guessed. Students could submit an answer as many times as necessary in order to gain feedback and eventually solve a problem. The assessments were time-consuming: most weeks of the course had just four assessments, but completing those four required 10–20 hours of work. Similarly relevant performance assessments have been used in courses such as chemistry, biology, physics, and computer science. Such complex assessments, if pooled for a given student across many courses, can give rich data about problem-solving skills and collaborative activity.

Furthermore, researchers can collect fine-grained data about the actions of an individual student. This data can provide specifics about learning trajectories from both correct and incorrect answers and about the actions taken to get there. Extensive research shows differences in the problem-solving strategies of novices and experts. Experts can chunk information; for example, an expert looking at an analog circuit will be able to remember that circuit, whereas a novice will not, likely leading to differential patterns of behavior such as scrolling.[6] Data from rich assessments may provide information on the development of such expertise. We can also record how many times a student flips between pages of a problem set or looks up equations in a textbook, and we can then investigate which of these variables contain data that can act as proxies for expertise.

As increased amounts of digital group work are introduced into courses, more traces of social activity appear in server log files. These logs can help to identify students who underperform or overperform in group tasks and can directly measure individual students' contributions to the group. These systems may provide enough data to begin to look for specific actions and patterns that lead to good overall group performance. Feedback can be provided to students by using these patterns to improve group performance. Natural language processing frameworks, such as the open-source edX EASE and Discern, are still used primarily for short-answer grading, but they were designed to apply also to the analysis of social activities, such as emails and forum posts. These frameworks promise to provide insights into writing processes and group dynamics.[7]

Finally, aside from looking within individual courses, MOOC data systems allow longitudinal analysis across a student's educational trajectory. In most cases, a single time point does not provide interesting information about learning. However, reviewing all of the projects over the duration of a student's education can provide more precise estimates of learning and proficiency. Learning analytics systems are increasingly moving in the direction of aggregating information from multiple sources across multiple courses. Open analytics architectures, such as edX Insights or Tin Can, provide a common data repository for all of a student's digital learning activities.

The rise of big data is significant not only because of the new methods that extract data from existing contexts, but also because of the new contexts.

Data Creation

Many analytic pitfalls arise from a failure to ask the question "Where does data come from?" The phrases *data collection* and *data mining* both suggest that data simply exists for researchers to collect and mine. From educational research, we think a more useful perspective is that of *data creation,* because it focuses analysts on the process that originally generated the data. From this perspective, the rise of big data is significant not only because of the new methods that extract data from existing contexts, but also because of the new contexts. If we create a MOOC or an online educational game or a learning management system or an online assessment, we are enabling the collection of data, true, but we are

Kaltura unites all of your video tools into one powerful platform. With integrations with every LMS, portable data through the Open Capture Standard and Caliper analytics, and cutting-edge engagement tools like interactive video quizzing, personal media capture, and webcasting, Kaltura helps you take advantage of the power of video across every department on campus.

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also, and more important, creating data in a new context, a context that happens to enable its collection.

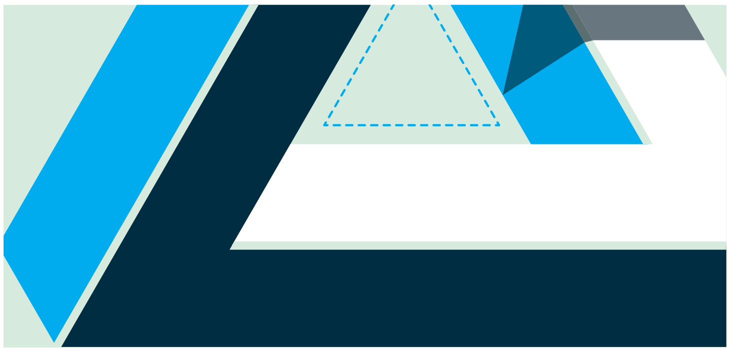
This is a consequential perspective because it discourages lazy generalizations and false equivalences. Previous work described MOOCs not as new courses but as new contexts, in which conventional notions of enrollment, participation, curriculum, and achievement require reconceptualization.[8] This description focused on the reasons MOOCs are different from seemingly analogous learning contexts in residential and online education: MOOCs are characterized by heterogeneous participants, asynchronous use, and low barriers to entry. In the context of MOOCs, one could argue that dropout is a *desired* outcome for many MOOC participants, simply because many participants intend to browse and explore for a (possibly imperfect) fit.[9] Research that tries to increase completion rates should therefore address whether MOOC completion is, in fact, preferred over a counterfactual activity and should subset to those for whom this is true. Other analytic challenges in MOOC research include differential attrition from treatment groups and heavily skewed distributions.[10]

Beyond MOOCs, any line of work based on a data-intensive or big data orientation should be understood within the context of the processes that generate the data. When the context and the process are particular, as they often can be in big data educational research, disambiguating features of the particular context with general contributions to the cognitive science of learning can be difficult. Big data research does not inherently imply replicability across contexts. Nonetheless, big data can enable linkages to other datasets from other contexts, in turn, enabling an assessment of generalizability of findings to these contexts.

Defining (and Committing to) the MOOC "Student"

We have argued for viewing data-intensive contexts in education not as familiar contexts with data but as unfamiliar contexts that enable data collection. We believe this perception can productively refocus research on describing these contexts and determining whether and how research findings within them generalize to contexts that are more familiar. Studies of Harvard and MIT open online courses have found considerable variation in participants' age, education, and geography,[11] along with many teachers enrolled in the courses and varying levels of initial commitment.[12] We and others have argued that this makes evaluating MOOCs extremely difficult, with the uncritical use of "completion rates" as an outcome variable being particularly problematic. This difficulty presents a challenge: defining and agreeing on MOOC metrics.

What differentiates an *online course* from *online content*? One possible answer is that content can be consumed or not consumed with little care, but in a course, providers and students have a mutual sense of commitment to specific learning goals. In a course, if learning does not happen, the student should be disappointed—and so should the institution. That failure to learn should be remedied. Another possible answer is that courses have active learning activities and structure, whereas content is passive and free-form. This active approach, one that constantly uses data to offer feedback to instructors and students, is part of the promise of data-intensive research and analysis in higher education.



Any line of work based on a data-intensive or big data orientation should be understood within the context of the processes that generate the data.

Content alone is a contribution, and content alone is indeed all that some instructors and institutions may be interested in providing. However, providing only open content makes MOOC completion most likely for learners who know what they need, who are self-motivated, and who have the time and skills necessary to keep themselves in the zone of proximal development as the course progresses. The general finding that MOOC registrants are disproportionately college-educated and, in the United States, come from affluent neighborhoods is consistent with this hypothesis.[13] Without other elements of schooling—for example, credible credentialing, remediation, and accountability—MOOCs are unlikely to close achievement gaps in the United States without targeted interventions, which only some MOOCs offer. Gap closure is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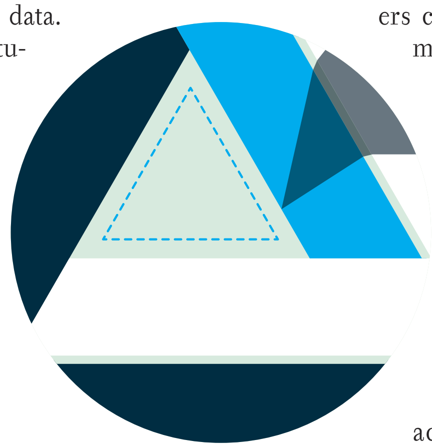
neither necessary nor sufficient for positive impact, since MOOCs have raised levels of access at a large scale. However, to the extent that gap closure is a goal, such efforts require significant resources and a dedicated mission—as will also big data efforts if they are to remedy achievement gaps.

In order to self-evaluate, MOOC purveyors could establish a definition of a *committed learner* and make this definition clear to registrants and the public. One working definition of a *committed learner* might be a registrant who (1) states a commitment to completing the course and (2) spends at least 5 hours active online. This seems a sufficient amount of time for a student to understand what she or he is getting into (a "shopping period") and results in a completion rate of 50 percent (using Harvard and MIT data). According to another definition—used by many existing MOOC providers—a *committed learner* is one who attempts at least one problem on one assignment. This has given a completion rate very close to 25 percent for MOOCs that reported such data. Instructors and institutions could publish counts of committed learners along with their completion rates, could be held accountable to them, and could strive to improve their counts and rates from baseline rates.



Importantly, this definition of a committed learner does not exclude other participants. Under this model, browsers who are curious, auditors who merely want access to videos, and teachers who are seeking materials may use MOOCs as they please, and such learners could be further segmented with appropriate metrics for how well MOOCs serve their needs. Once instructors and administrators know who their participants are, the pedagogical instinct is to hold the instructors and administrators accountable to helping MOOC participants achieve their goals. This instinct is analogous to the opportunity that big data presents in residential higher education.

Data for Prediction or for Learning?

The most common questions being asked of digital learning data involve prediction, including prediction of certification, attrition, and future outcomes such as course-taking patterns. But it's worth remembering that in any formative educational process, the criterion for prediction is not accuracy, as measured by the distance between predictions and outcomes. Instead, the criterion is impact, as measured by the distance between student learning with the predictive algorithm in place and student learning had the algorithm not been in place. We find the emphasis on technically sophisticated predictive models and intricate learning pathways to be disproportionate, and we think there is too little attention being paid to rigorous experimental designs for ascertaining whether students and instructors can use these tools to increase learning.

In short, we want educational predictions to be wrong. If our predictive model can tell that a student is going to fail, we want that to be true only in the absence of intervention. If the student does in fact fail, that should be seen as a failure of the system. A predictive model should be part of a prediction-and-response system that (1) makes predictions that would be accurate in the absence of a response and (2) enables a response that renders the prediction incorrect (e.g., to accurately predict that, given a specific intervention, the student will succeed). In a good prediction-and-response system, all predictions would ultimately be negatively biased. The best way to empirically demonstrate this is to exploit random variation in the assignment of the system—for example, random assignment of the prediction-and-response system to some students but not all. This approach is rarely used in residential higher education but is newly enabled by digital data.

Assessing Complex Skills in MOOCs

Pedagogical Design

Making measurement an objective of instructional design can create substantial challenges. Assignments and assessments in courses have several objectives:

- *Serve as an ongoing means of monitoring what students know.* This allows instructors and students to tailor teaching and learning to problematic areas.[14]
- *Serve as the principal means by which*

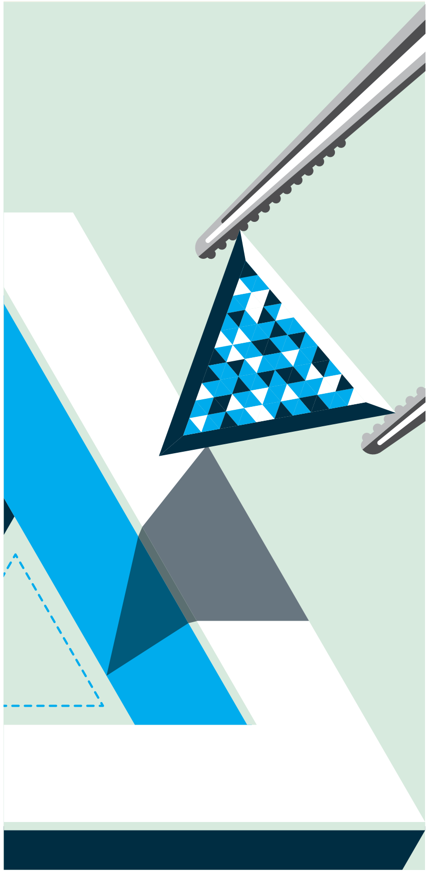
students learn new information. In many subjects, most learning happens through assignments in which students manipulate, derive, or construct knowledge—not through lectures, videos, or readings.[15]

- *Serve as a key component of grading.* Grading has multiple goals, from certifying students' accomplishments to providing motivation for desired behaviors by students.
- *Serve as a summative assessment of students, teachers, institutions, and courses.* Summative assessment has many high-stakes goals, such as student certification and school accreditation.

Different research communities emphasize different objectives and therefore give very different principles for how good assessments ought to be constructed. For example, a quantitatively oriented psychometrician may emphasize reliability and comparability, which generally requires a high level of standardization. In contrast, the physics education research community may emphasize concepts such as deliberate practice, rapid feedback, active learning, and constructive learning.[16]

Conclusion

Although many of the goals of an educational experience cannot be easily measured, data-intensive research and analysis in higher education can help us improve, control, and understand those goals that *can* be measured. The breadth and depth of the data now available has the potential to fundamentally improve learning. We believe that what is happening with data-intensive research and analysis today is comparable to the inventions of the microscope and the telescope. Both of these devices revealed new types of data that had always been present but never before accessible. We now have the equivalent of the microscope and the telescope for understanding teaching and learning in powerful ways.



Data-intensive research and analysis in higher education can help us improve, control, and understand those goals that can be measured.

Digital assessments have long been an effective means for freeing up instructors' time, particularly in blended learning settings, as well as for providing immediate formative feedback.[17] Building on this work is the move to authentic assessment, to approaches in which humans and machines work in concert to quickly and accurately assess and provide feedback on student problems, where data is integrated from very diverse sources, and where data is collected longitudinally.[18]

With this shift we have, for the first time, data about virtually all aspects of students' skills, including the complex abilities that higher education attempts to foster—abilities that, in the modern economy, are more important than simple factual knowledge.[19] We have the potential to assess postsecondary learners in ways that can improve depth, frequency, and response time, possibly expanding the scope with which students and instructors can monitor learning, including assessment of higher-level skills, and proving personalized feedback based on those assessments. However, the tools for understanding this data (e.g., edX ORA, Insights, EASE, and Discern) are still in their infancy. The grand challenge in data-intensive research and analysis in higher education is to find the means to extract such knowledge from the extremely rich data sets being generated today and to integrate these understandings into a coherent picture of our students, campuses, instructors, and curricular designs. ■

Notes

1. In response to these challenges, the Computing Research Association (CRA) convened a two-workshop sequence on data-intensive research, with experts exchanging ideas with other scholars in the field and with program officers from the National Science Foundation (NSF). This article summarizes and extends ideas and insights from the second workshop, which centered on big data in education. We would like to thank the participants in the CRA workshop for their intellectual contributions to this article, and we also thank the NSF and CRA for helping to fund and organize the workshop. The viewpoints expressed here are those of the authors and are not official positions of the NSF as the funder. The report from this workshop is available online.
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4. We define *at-scale* learning environments as ones in which thousands of students share common digital resources and for which we collect data about their use. This data includes not only

MOOCs but also many educational technologies predating MOOCs, as well as formats such as small private online courses (SPOCs) where common resources are used across many classrooms.

5. The course was used both in a pure online format and in a blended format at a number of institutions. Piotr F. Mitros et al., "Teaching Electronic Circuits Online: Lessons from MITx's 6.002x on edX," *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS)*, Beijing, China, May 2013.
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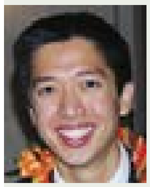

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Moving the Red Queen Forward: Maturing Analytics Capabilities in Higher Education

By Eden Dahlstrom

IN Lewis Carroll's *Through the Looking-Glass*, Alice finds herself running hand in hand with the Red Queen. The Queen prompts Alice to run faster and faster, since they are almost "there." At the point of exhaustion, Alice stops and is propped against a tree by the Queen. With surprise Alice realizes that they haven't moved beyond their starting point, despite all the running:

"Everything's just as it was!"

"Of course it is," said the Queen, "what would you have it?"

"Well, in *our* country," said Alice, still panting a little, "you'd generally get to somewhere else—if you ran very fast for a long time, as we've been doing."

"A slow sort of country!" said the Queen. "Now, *here*, you see, it takes all the running *you* can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"[1]

This article is drawn from the recent research by the EDUCAUSE Center for Analysis and Research (ECAR) and Gartner researchers on the state of analytics in higher education. This research explores the analytics trends as well as future predictions for the deployment of analytics technologies. Publications include *The Analytics Landscape in Higher Education, 2015*; *Institutional Analytics in Higher Education*; and *Learning Analytics in Higher Education*. More information about the analytics maturity index and deployment index can be found in the EDUCAUSE Core Data Service (participating) and the EDUCAUSE Benchmarking Service.

ILLUSTRATION BY STEVE McCRACKEN, © 2016

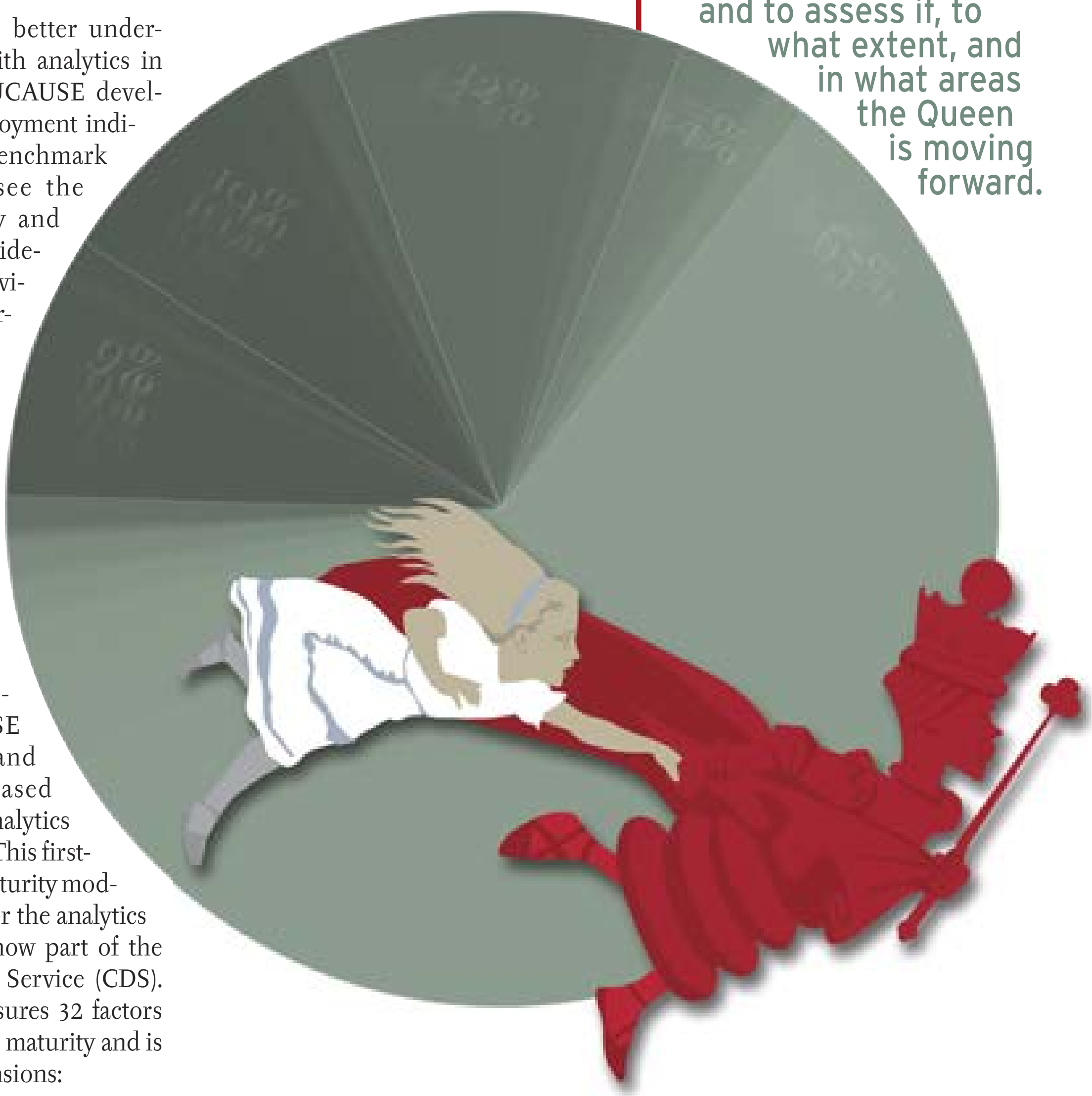
The Red Queen metaphor is particularly relevant to understanding the progression of analytics capabilities in higher education over the last few years. The intended destination is to "do" analytics—use data, statistical analysis, and explanatory and predictive models to gain insight and act on complex issues—across the business and learning domains of higher education.[2] The question is, Are we getting closer to our destination? Or are many of our institutions, like the Red Queen, running twice as fast (working twice as hard) to stay in pretty much the same place? In what areas are we leading or lagging, and how can we make progress to mature our analytics capabilities—that is, to move the Red Queen forward on the analytics chessboard?

To help institutions better understand their progress with analytics in higher education, EDUCAUSE developed maturity and deployment indices to measure and benchmark analytics practices (see the "EDUCAUSE Maturity and Deployment Indices" sidebar p. 41). By providing evidence regarding the current levels of analytics development, identifying areas of strength and weakness, and formulating responses that proactively move the proverbial needle in the desired direction, these indices can help institutions engage in analytics strategic planning and management. The EDUCAUSE Center for Analysis and Research (ECAR) released the first stand-alone analytics maturity index in 2012. This first-generation version of maturity modeling served as a basis for the analytics maturity index that is now part of the EDUCAUSE Core Data Service (CDS). The current index measures 32 factors contributing to analytics maturity and is organized into six dimensions:

1. *Decision-making culture,* including senior leadership commitment and the use and cultural acceptance of analytics
2. *Policies,* including data collection, access, and use policies
3. *Data efficacy,* relating to quality, standardization, and "rightness" of data and reports and the availability of tools and software for analytics
4. *Investment/resources,* consisting of funding, an investment-versus-expense mentality, and the appropriateness of analytics staffing
5. *Technical infrastructure,* consisting of analytics tools and the capacity to store, manage, and analyze data
6. *IR involvement,* capturing interaction between the IT and the IR (institutional research) organizations[3]

A score on a scale of 1 (absent/ad hoc) to 5 (optimized) is calculated for each of the dimensions, and the mean of those scores is the overall institutional maturity score. This score provides a way for an institution to determine where its analytics Red Queen is and to assess if, to what extent, and in what areas the Queen is moving forward.

This score provides a way for an institution to determine where its analytics Red Queen is and to assess if, to what extent, and in what areas the Queen is moving forward.



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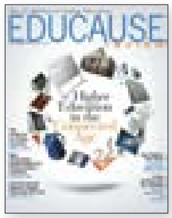
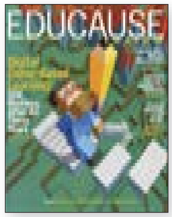
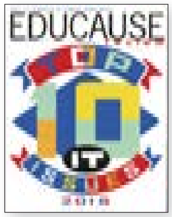


Twelve MAGGIE Awards, including two for “Associations, Nonprofit/Trade (Print) Magazine”

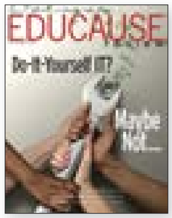


Eight Tabbie Awards, including five for “Best Single Issue.”

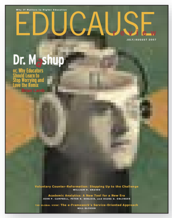


Nine Azbee Awards, including “National Top Ten, General Excellence, Magazine of the Year”

Ten Magnum Opus Awards for Outstanding Achievement in Custom Publishing, including two Silver Awards and two Gold Awards for “Best All-Around Association Publication”

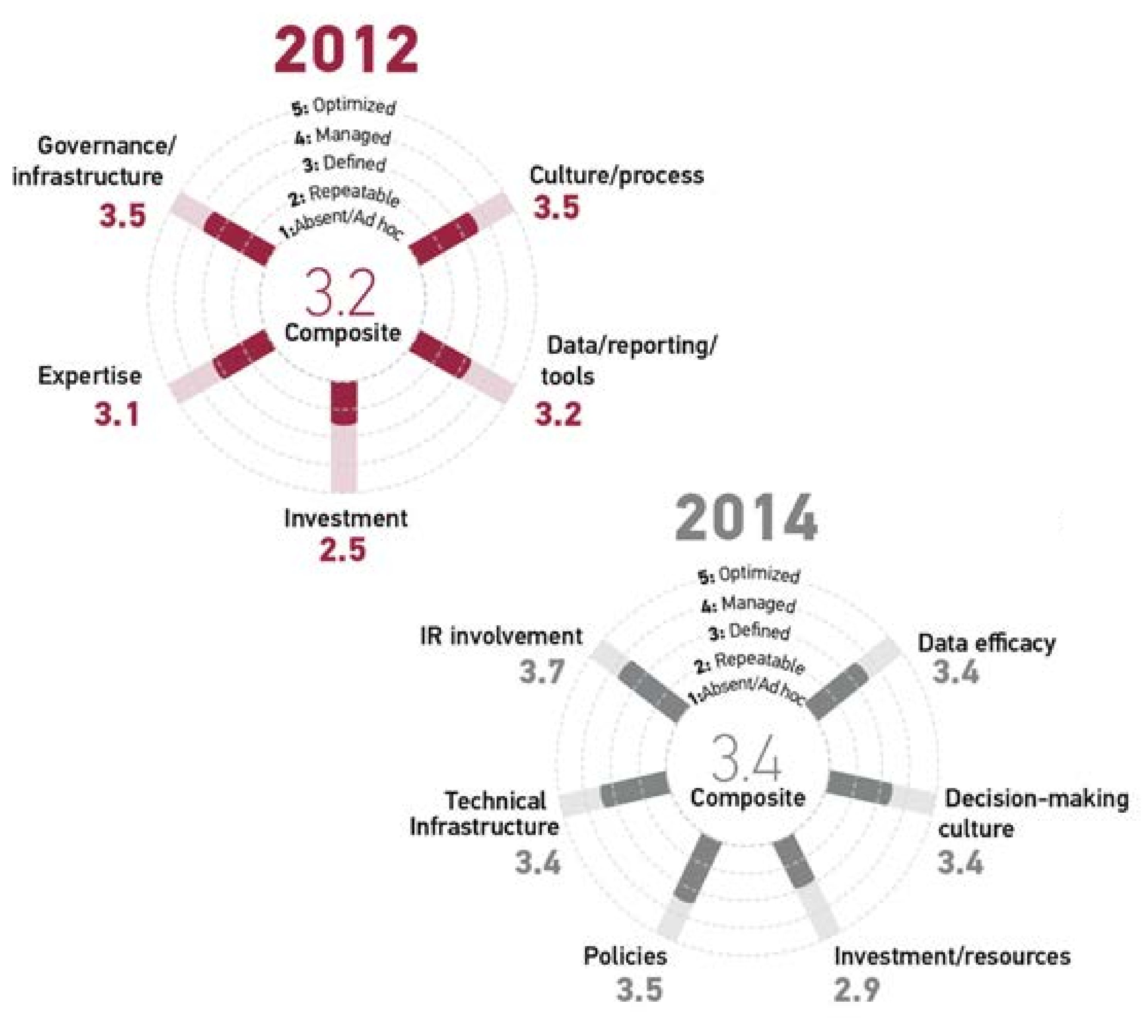


Six Ozzie Awards for Excellence in Magazine Design, including a Bronze Award for “Best Use of Illustration”



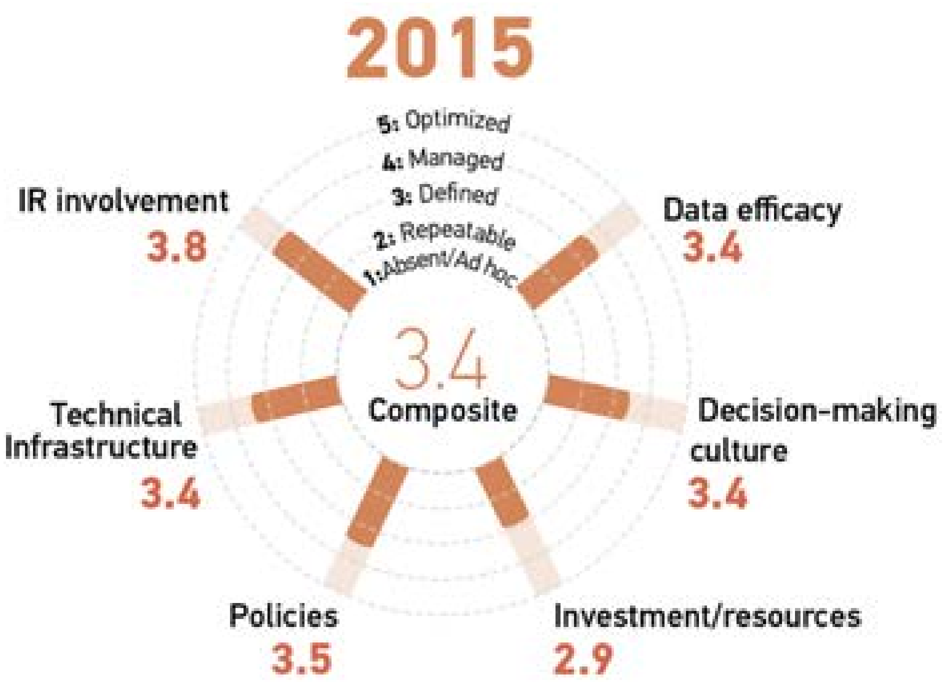
EDUCAUSE Review, the flagship magazine of EDUCAUSE, takes a broad look at current developments and trends in information technology, how they may affect the college or university as an institution, and what they mean for higher education and society. In addition to EDUCAUSE members, the magazine’s audience consists of presidents and chancellors, senior academic and administrative leaders, non-IT staff, faculty in all disciplines, librarians, and corporate leaders. The magazine has a print bimonthly circulation of 22,000 and a monthly online readership of 100,000+.

FIGURE 1. EVOLUTION OF ANALYTICS CAPABILITIES



Analytics Maturity in Context

Analytics has made the EDUCAUSE annual Top 10 IT Issues lists for four of the last five years, solidifying the issue as one with relevance and enduring strategic importance. When EDUCAUSE first measured analytics maturity as part of the 2012 ECAR research study *Analytics in Higher Education: Benefits, Barriers, Progress, and Recommendations*,[4] we calculated an overall composite maturity rating of 3.2 (mean on a 5-point scale across all factors). For the 339 IT and IR leaders who responded to that survey, the middling (not too low and not too high) assessment was not surprising, given that the marketspace for analytics technologies, tools, and talent was still somewhat limited. Since 2012, the resources in the analytics marketspace have expanded, so it was somewhat surprising (at first glance) to find that the overall composite maturity rating across higher education had inched ahead to only 3.4 in 2014 and was flat (3.4 again) in 2015 (see figure 1).[5] Yet though the



Source: Jacqueline Bichsel, *Analytics in Higher Education: Benefits, Barriers, Progress, and Recommendations* (Louisville, CO: ECAR, 2012); EDUCAUSE Core Data Service, 2014 and 2015.

EDUCAUSE Maturity and Deployment Indices

EDUCAUSE uses maturity and deployment indices to track higher education's progress in delivering IT services. *Maturity indices* measure the capability to deliver IT services and applications in a given area. They examine multiple dimensions of progress (not just technical ones) such as culture, process, expertise, investment, and governance. They enable institutions to determine where they are and where they aspire to be. *Deployment indices* measure stages of deployment for specific technologies and services, which are aggregated to track progress in a domain. The analytics maturity and deployment indices are based on contributions to the EDUCAUSE Core Data Service, an annual survey and benchmarking service open to all higher education institutions.

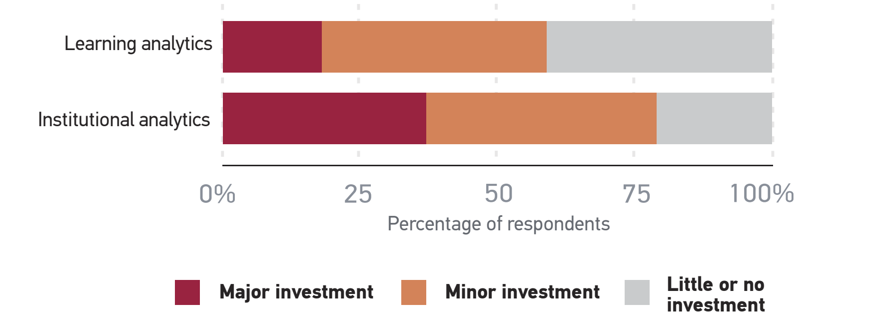
Source: More information can be found via the EDUCAUSE Benchmarking Service (http://educause.edu/benchmarking).

practical significance of moving from a mean 3.2 to 3.4 composite maturity score over three years is not impressive at face value, this change represents a statistically significant step forward for the community's overall mean. Any upward movement of the needle represents marked improvement in maturing analytics capabilities. So perhaps the Red Queen *is* moving forward, just at a disproportionately slow pace when contrasted to the level of interest among higher education leaders.

Investment/Resources: The Least Mature Dimension of Analytics

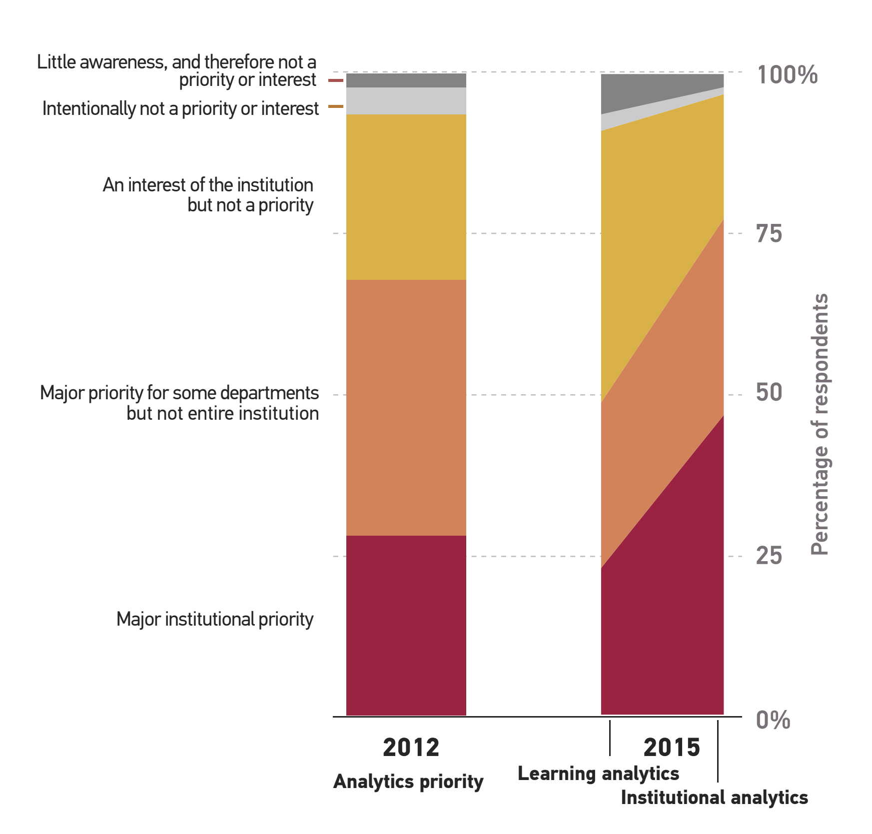
Individual maturity index dimension scores remained relatively consistent from year to year. Responses for each are expectedly anchored near the midpoint of the 5-point scale used to measure maturity. Individual mean maturity scores remained the same in 2015 as they were in 2014.[6] IR involvement is notable because it endures as the most advanced dimension; it is not uncommon to find the Director of Institutional Research in a leadership or significant support role in analytics. On the other hand, the dimension of investment/resources endures as the least advanced. "Despite widespread interest, analytics is still not regarded as a major institutional priority

FIGURE 2. INVESTMENT IN ANALYTICS



Source: Ronald Yanosky, with Pam Arroway, *The Analytics Landscape in Higher Education, 2015* (Louisville, CO: ECAR, 2015), 8.

FIGURE 3. PRIORITY OF ANALYTICS



Source: Ronald Yanosky, with Pam Arroway, *The Analytics Landscape in Higher Education, 2015* (Louisville, CO: ECAR, 2015), 7.

at most institutions. Investment is more often described as minor rather than major. Institutions where analytics is a major priority are more likely to report a major investment in it" (see figure 2).[7]

Investment in institutional analytics (i.e., analytics intended to improve services and business practices across the institution) exceeds investment in learning analytics (i.e., analytics intended to improve student success). This awareness provides some insight as to what drives investment decisions. Learning analytics is primarily driven by improving student retention; institutional analytics is primarily driven by optimizing resources. That said, two of the top three drivers for both types of analytics are the same: improving student retention and demonstrating the value of higher education's effectiveness. These two drivers provide a return on investment for learning analytics *and* institutional analytics. As noted by the 2015 ECAR research study *The Analytics Landscape in Higher Education:* "Improving student retention, reducing students' time to degree, and improving student course-level performance (and therefore reducing remediation or dropout) are good business practices that also directly support student success."[8] The differentiator in what motivates greater investment in institutional analytics over learning analytics is interest in optimizing resources. The promise of analytics to realize institutional business interest to improve operational efficiencies and optimize business practices fuels investment.

Interest, Priority, and Investment

Investment in analytics is the natural result of analytics becoming an institutional priority and gaining widespread institutional interest. Taking a closer look at the relationship between interest, priority, and investment provides insight about why investment/resources in analytics lags behind the other dimensions. In the 2012 ECAR research study, approximately two-thirds (69%) of respondents said that analytics was a major priority for at least some departments, units, or programs and that it would gain importance over the next two years. In the 2015 ECAR research study, this prediction proved true for institutional analytics (77% of respondents said it was a priority) but not for learning analytics (49% of respondents said it was a priority) (see figure 3).[9]

Investment Opportunity: Talent

There are three major investment opportunities for maturing analytics capabilities: talent, technology, and tools. Analytics talent is tracked in two places, primarily in the EDUCAUSE maturity

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3/13–3/14 | Portland, OR

Management Boot Camp
3/13–3/14 | Portland, OR

NERCOMP Annual Conference
3/27-3/29 | Providence, RI

APRIL

EDUCAUSE Connect
4/10–4/11 | Chicago, IL

New IT Managers Program
4/10–4/11 | Chicago, IL

Management Boot Camp
4/10–4/11 | Chicago, IL

MAY

Security Professionals Conference
5/1–5/3 | Denver, CO

JUNE

Leading Change Institute
6/11–6/17 | Washington, DC

JULY

Leadership Institute
7/10–7/14 | Long Beach, CA

Management Institute
7/24–7/28 | Long Beach, CA

Learning Technology Leadership Institute
7/24–7/28 | Long Beach, CA

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EDUCAUSE Annual Conference
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EDUCAUSE

index and also in ECAR analytics research. In the maturity index, six of the nine items that make up the investment/resources analytics dimension are related to people (talent):

- We have IT professionals who know how to support analytics. (3.5)
- Our analysts know how to present processes and findings to stakeholders and to the broader institutional community in a way that is visually intuitive and understandable. (3.1)
- We have business professionals who know how to apply analytics to their areas. (3.0)
- We have dedicated professionals who have specialized analytics training. (2.9)
- We have a sufficient number of professionals who know how to support analytics. (2.5)
- We have an appropriate number of data analysts. (2.4)

The two least-developed talent items on the maturity index speak to *quantity* of staff, whereas the other four items speak to the *quality* of the staff already in place. This is an important point to note: the primary talent barrier to maturing analytics capabilities is the number of staff available to do the work, not the skills of current staff in analytics support roles.

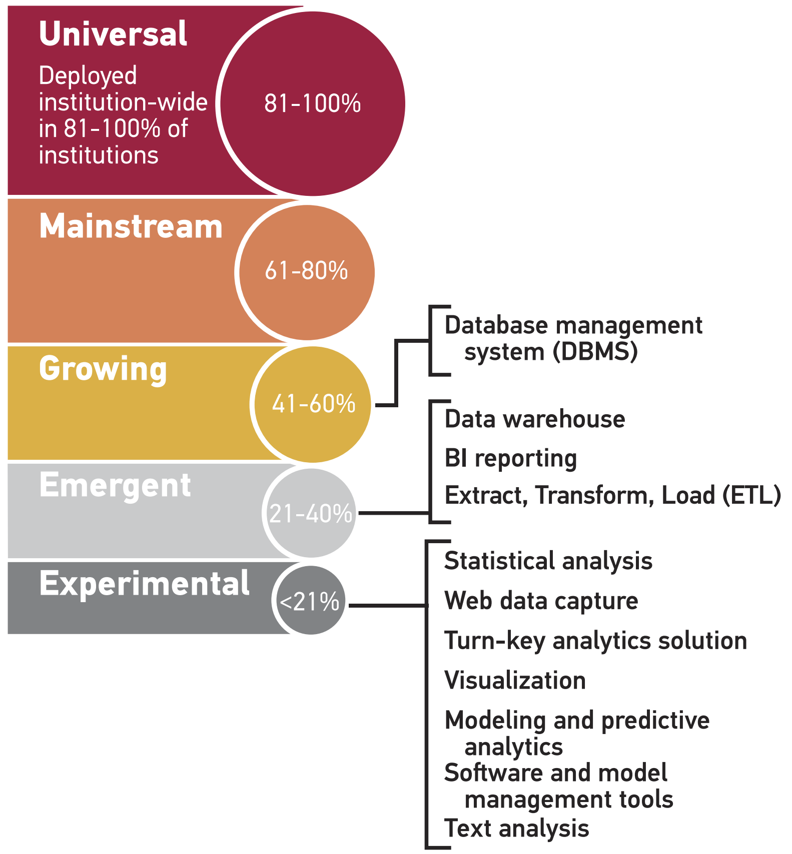
The 2015 ECAR research study identified which analytics staff roles are in place and which roles have the greatest need for more staff to support analytics. The top analytics roles needed are in predictive modeling (92% of institutions), analytics tool training (89%), data visualization (88%), user experience development (87%), and data analysis (87%). "All of these except data analysis are currently in place at fewer than 6 in 10 institutions. The near-universal desire to add predictive modeling skills indicates a wish to move from a reporting orientation to a higher order of understanding and action."[10]

Investment Opportunity:
Tools and Technologies

Shifting our focus to the tools and technologies that institutions need in order to mature the capacity for analytics, we look to the EDUCAUSE deployment index. This index complements the maturity index (which measures the institution's *ability to* deliver technologies and services) by measuring which technologies and services *are actually being delivered.* The analytics deployment index consists of 11 analytics services and technologies that subject matter experts identified as being key. Although these do not represent the entirety of analytics services and technologies that institutions are delivering, they do provide a basic overview of critical capacity-building resources for analytics (see figure 4).[11]

The clustering of the technologies on the lower part of the deployment index scale is quite telling; institution-wide deployment of technologies that support analytics are more commonly the exception than the rule. Most of the technologies that support analytics are considered experimental, with fewer than 21% of institutions reporting institution-wide deployment. When "targeted deployment" of technologies is added to "institution-wide deployment," four items migrate to mainstream status: database management system, data warehouse, BI reporting, and statistical analysis.

FIGURE 4. ANALYTICS DEPLOYMENT INDEX



Source: EDUCAUSE Core Data Service, 2015.

Shared Investments and Shared Success

Institutional interests in optimizing business practices and operational efficiencies are driving analytics maturity in higher education more than interests in improving student outcomes. However, it is important to note that these drivers are not necessarily mutually exclusive. Improving student retention, reducing students' time to degree, and improving student course-level performance (and therefore reducing remediation or dropout) are good business practices that also directly support student success. The lines between institutional analytics and learning analytics blur in these areas. Regardless of the motivation to invest in these factors, the return on that investment will be seen by those interested in improving the business model and by those interested in improving student outcomes.

Institutions won't likely find a "quick win" when it comes to learning analytics investments since measuring success metrics for student outcomes requires end-of-course, end-of-term, end-of-year, or end-of-matriculation assessment periods. Chief business officers (CBOs), CAOs, CIOs, and institutional research professionals, however, will enjoy the shared success of the initial investment in these areas.

Source: Ronald Yanosky, with Pam Arroway, *The Analytics Landscape in Higher Education, 2015* (Louisville, CO: ECAR, 2015), 10.

Moving from experimental to mainstream (to universal) will require significant investment in the resources that support (or grow) analytics capabilities in higher education. This provides a blue-ocean opportunity to bring affordable, quality analytics tools and technology products to market. Learning analytics is a major priority at about half as many institutions as institutional (business) analytics, so investing in the technologies and tools that support institutional analytics will likely precede investment in learning analytics (see the "Shared Investments and Shared Success" sidebar). With sufficient funding levels for analytics hitting only 2.6 out of 5 in the analytics maturity index, analytics leaders need to assess the value proposition of such tools and technologies and communicate the return on investment to campus leaders. Currently, low investment/resources scores from the analytics maturity index conceptually validate the deployment index findings. Greater investment will likely beget more of the technologies and tools that can mature institutional analytics capabilities.

ECAR's strategic technology research gives a sense of the types of technologies that institutions will invest in over the next five years.[12] Both business performance analytics and learning analytics top the list, with business analytics having greater velocity than learning analytics when it comes to adoption trends (see figure 5, p. 50). Five years from now, higher education will still be growing capacity to collect and use data for predictive analytics. Mobile apps and on-the-go dashboards will still be emergent. Using "big data" for either institutional or learning analytics will also still be emergent. In five years, higher education will probably have a handle on using data, statistical analysis, and explanatory models to gain insight and act on complex issues (most of the components featured in the definition of analytics). We will most likely still be developing and working on incorporating predictive modeling (the other component of the definition of analytics) to our business practices.

Advice for Moving the Red Queen Forward

Maturing the analytics capabilities at an individual institution is a function of the interaction of the institution's interests, priorities, and investments with the local conditions that hinder or foster progress toward a goal. The 2015 ECAR research study offers the following advice for moving the institution's analytics Red Queen forward.

IR Involvement

Creating an analytics program to enhance decision making across an institution is a collaborative effort. In 43% of the institutions surveyed, responsibility for analytics services is shared by IT and IR. For another 27% of institutions, responsibility for analytics is on IR. Cultivating effective communication between IT and IR departments is essential to building analytics maturity. "IR teams already know how to use data to support external reporting requirements. It might be possible to take advantage of the existing analytics staff skill sets and tools to focus on internal problems, as well, or at least to inform analytics strategy setting." Having a senior-level IR lead involved in the planning for high-level strategic initiatives or questions is also a factor in maturing an analytics program or service.

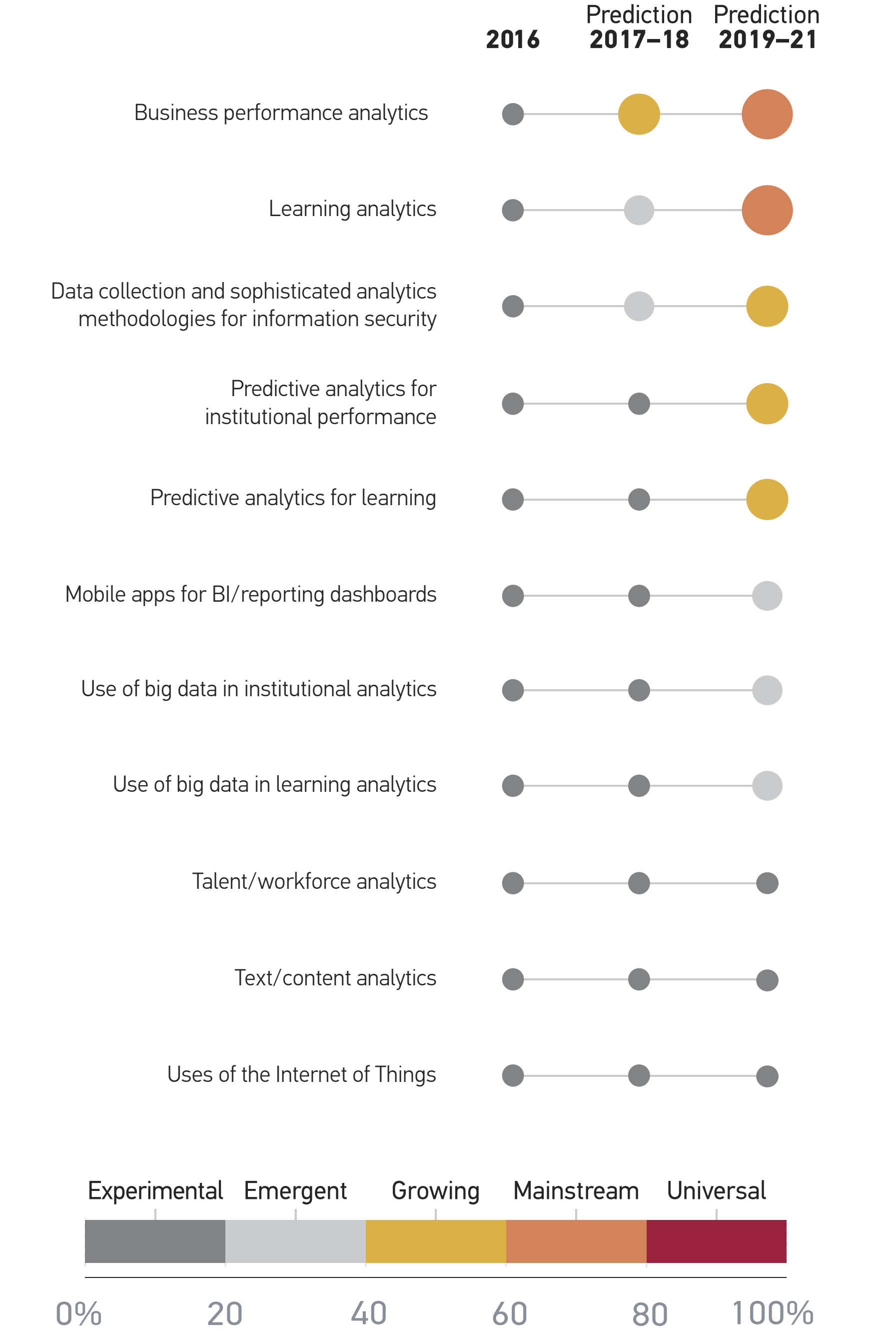
Technical Infrastructure

Basic technology elements that support analytics are widely available and are relatively up to date. BI tools were reported in place at 86% of CDS 2014 institutions, and data warehouses were in place at 77%. Almost three-quarters of institutions had both. Having analytics tools and software with the capacity to store, manage, connect, analyze, and interact with stakeholders is a sign of analytics maturity.

Decision-Making Culture

We mentioned earlier that institutions tend to view their analytics culture positively, though the feeling is hardly unanimous: A bare majority (53%) of CDS 2014

FIGURE 5. ESTIMATED FIVE-YEAR ADOPTION TRENDS FOR ANALYTICS TECHNOLOGIES



Source: Susan Grajek, *Higher Education's Top 10 Strategic Technologies for 2016*, research report (Louisville, CO: ECAR, January 2016), 38.

respondents agreed that their culture overall accepts the use of data to make decisions. Only about a third agree, however, that they have a process for moving from what data say to making changes or decisions. Strengthening change-management practices and incorporating data review formally into decision-making processes could help boost this crucial ability to act. This majority substantially exceeds, however, the 32% who agreed that faculty largely accept the use of analytics. If that sounds familiar, be sure to regularly take the pulse of the faculty community's willingness to use data to make decisions. EDUCAUSE research shows that the strongest motivator to get faculty to incorporate technology into teaching is evidence that students benefit; the same might hold for receptivity to analytics. Identify pockets of individuals who are unconvinced and target examples to questions or problems that directly affect them.

Policies

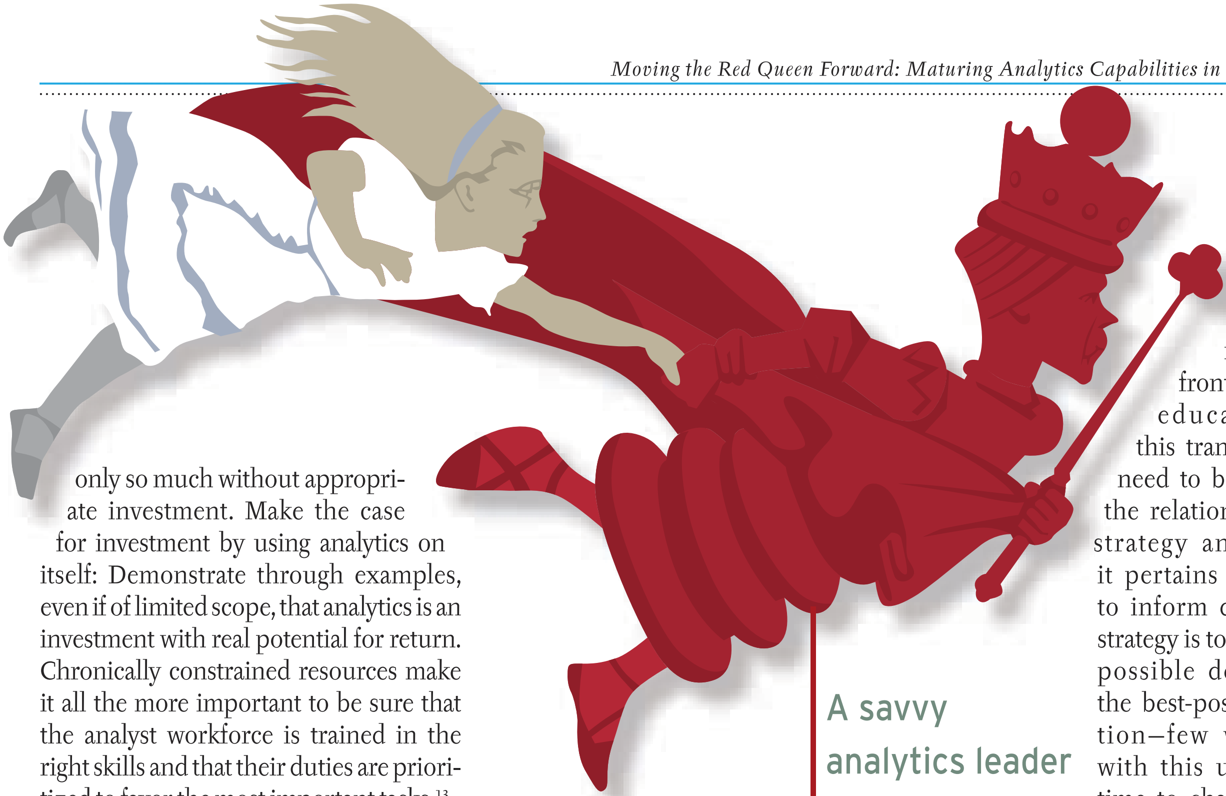
This is another area where institutions tend to rate themselves positively, but weaknesses here tend to derive from inadequate policies and practices in information security and in institutional review boards. Fortifying policies in these areas is an essential step toward analytics maturity. Consider creating mechanisms to communicate analytics plans, goals, and achievements to major constituents. As one focus group member put it, "Success is really just trust."

Data Efficacy

Institutions rate themselves low on data standardization, especially in support of external comparisons, and on processes for weeding out reports that no longer have value. To address such issues, work on improving data standardization; develop processes to eliminate, phase out, or update data and reports that are no longer valuable; and enhance user access to data with self-service tools like dashboards or portals. . . . Focus group members emphasized the need to identify all those who touch, view, or use data and to train them in the practices of good data stewardship.

Investment/Resources

It doesn't take long to understand why this dimension is the laggard. Only one in five institutions agreed that it has sufficient funding to meet current needs, and a dismal 13% said they have an appropriate number of data analysts. Facile advice to "get more money" isn't appropriate here, but it is necessary to face the fact that analytics can accomplish



only so much without appropriate investment. Make the case for investment by using analytics on itself: Demonstrate through examples, even if of limited scope, that analytics is an investment with real potential for return. Chronically constrained resources make it all the more important to be sure that the analyst workforce is trained in the right skills and that their duties are prioritized to favor the most important tasks.[13]

The study continues by making the following eight recommendations:

- Define strategic needs and priorities.
- Know where you stand.
- Build the case for investment.
- Think about the whole mission.
- Provide analytics leadership.
- Embrace collaboration.
- Develop people and skills before tools.
- Educate yourself about analytics trends.[14]

Finally, institutional leaders should also look to the challenges and successes of their peers' experiences with analytics initiatives.[15] They should find ways to learn from these challenges and to adapt or improve on these successes in the context of their own institutions. As an institution builds a capacity for analytics, its comprehension of the possibilities offered by analytics solutions will improve. In turn, this will increase the institutional appetite for easy-to-access, easy-to-understand, relevant, and accurate data to inform decisions.

Not Waiting for Godot

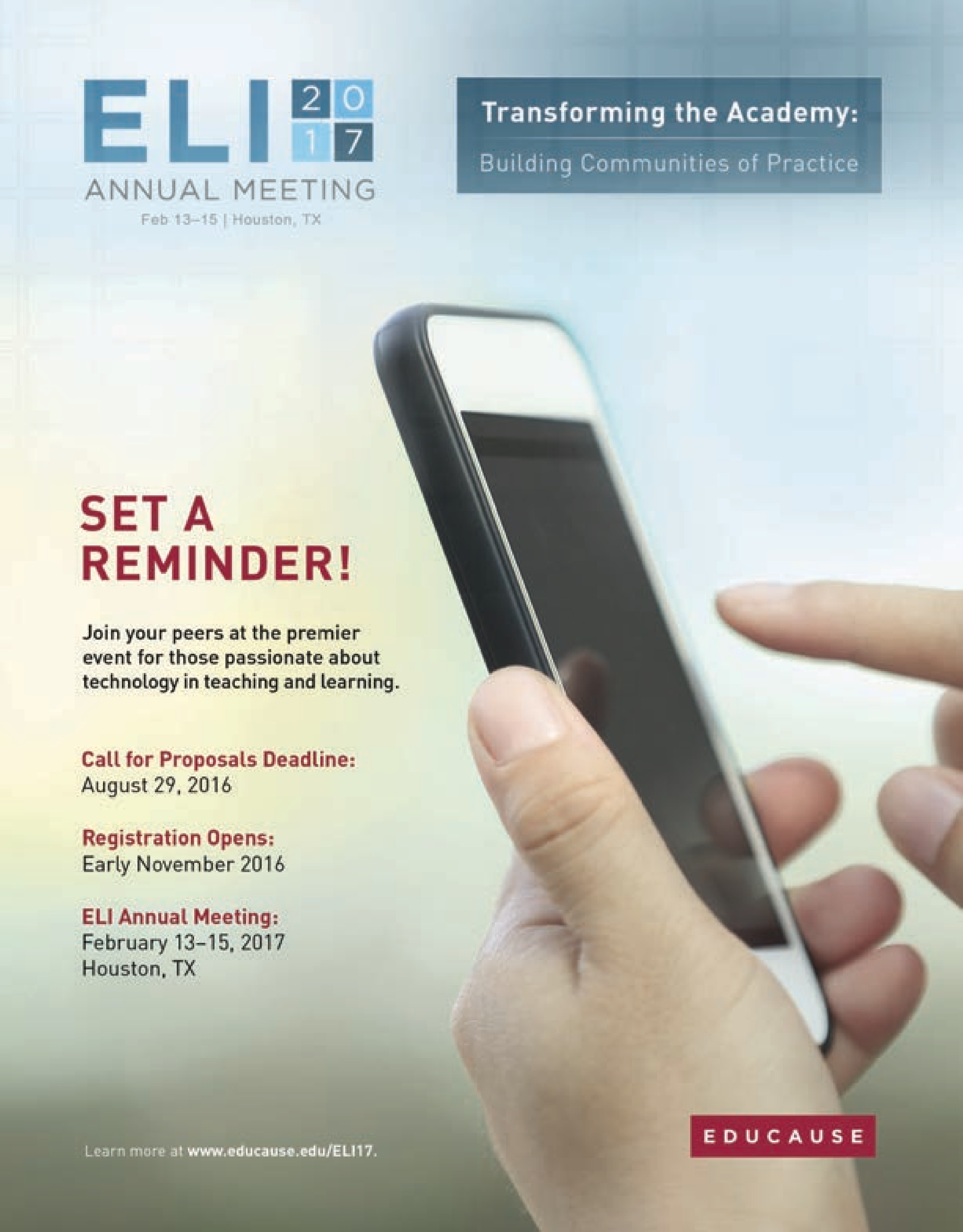
Carroll's storyline about moving the Red Queen forward in *Through the Looking-Glass* is a dramatic metaphor for the lack of marked progress in higher education analytics maturity over the past few years. Although individual institutions are making strides, the replicability and the scalability of these successes have yet to permeate across our campuses. Still, at least we aren't waiting for (the never-to-arrive) Godot when it comes to analytics.[16] The centrality of analytics will ensure that the analytics discussion continues over the next few years. "The forces driving analytics interest remain potent: pressure to find new students, meet accreditation requirements, respond to performance-based funding formulas, improve student success, and take advantage of a gusher of educational 'big data.'"[17]

Gone are the days of basing decisions on information generated exclusively from human advisors; we are approaching the era of analytics-driven machine-generated advisory services supported by coders/

A savvy analytics leader will be able to translate the benefits of analytics for a nontechnical stakeholder audience and will communicate a shared vision that can be used to influence and persuade the institution's decision makers.

programmers on the back end and by human storytellers on the front end. As higher education makes this transition, we will need to be cognizant of the relationship between strategy and culture as it pertains to using data to inform decisions. The strategy is to make the best-possible decision using the best-possible information—few will disagree with this until it comes time to change behaviors or practices. Management consultant Peter Drucker is credited with the statement "culture eats strategy for breakfast"—a statement that Vala Afshar, Chief Digital Evangelist at Salesforce, pointedly adapted to: "Culture takes strategy to lunch, has a wonderful conversation, and picks up the check. Culture and strategy are friends."[18] A savvy analytics leader will understand how to frame analytics investment in such a way that culture and strategy are friends, not foes.

This leader will also be able to translate the benefits of analytics for a nontechnical stakeholder audience, will serve as a mediator between those with technical expertise and practical business needs, and will communicate a shared vision that can be used to influence and persuade the institution's decision makers.[19] With analytics leadership, institutions will be able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to move the Red Queen forward—increasing their capabilities across the six dimensions of the analytics maturity index—without having to run twice as fast. ■

Notes

1. Lewis Carroll, *Through the Looking-Glass, and What Alice Found There* (1871; London: Oxford University Press, 1971).
2. Jacqueline Bichsel, *Analytics in Higher Education: Benefits, Barriers, Progress, and Recommendations* (Louisville, CO: ECAR, 2012).
3. These six dimensions vary from the original five used in the 2012 maturity index. This second-generation model adjusts the dimension names and contributing factors to better align with institutional practices. This updated analytics maturity model is part of the EDUCAUSE Benchmarking Service launched in January 2016.
4. Bichsel, *Analytics in Higher Education.*
5. The audience and instrument can vary from year to year, so we don't go as far as to say that not much progress has been made within institutions. The maturity index composite scores are best used as benchmarks for the industry overall rather than as self-improvement or peer-comparison benchmarks.
6. The mean maturity score for IR involvement increased from 3.7 to 3.8—a minor and not statistically significant increase.
7. Ronald Yanosky, with Pam Arroway, *The Analytics Landscape in Higher Education, 2015* (Louisville, CO: ECAR, 2015), 4.
8. Ibid., 10.
9. Bichsel, *Analytics in Higher Education*, 8; Yanosky and Arroway, *The Analytics Landscape in Higher Education*, 7.
10. Yanosky and Arroway, *The Analytics Landscape in Higher Education*, 19.
11. EDUCAUSE Core Data Service, 2015.
12. Susan Grajek, *Higher Education's Top 10 Strategic Technologies for 2016*, research report (Louisville, CO: ECAR, January 2016).
13. These six paragraphs were excerpted from Yanosky and Arroway, *The Analytics Landscape in Higher Education*, 26–29.
14. Ibid., 30–31. Expanded details for each recommendation are available in the report.
15. See Leah Lang, "Next-Level Benchmarking: How Do You Measure Up?" *EDUCAUSE Review*, June 13, 2016.
16. In Samuel Beckett's play *Waiting for Godot*, two characters wait, in vain, for someone named Godot. Conceptual credit for the Godot reference goes to Vince Kellen, CIO at UC San Diego.
17. Yanosky and Arroway, *The Analytics Landscape in Higher Education*, 5.
18. Vala Afshar (@ValaAfshar), July 10, 2013, 12:34 PM, Tweet.
19. See *Technology in Higher Education: Defining the Strategic Leader*, research report (Bristol, UK, and Louisville, CO: Jisc and EDUCAUSE, 2015).

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URGENT NEED
TO CONFIRM
MY IDENTITY?

EDUCAUSE RESEARCH SNAPSHOT

LEVERAGING TECHNOLOGY
to better engage students

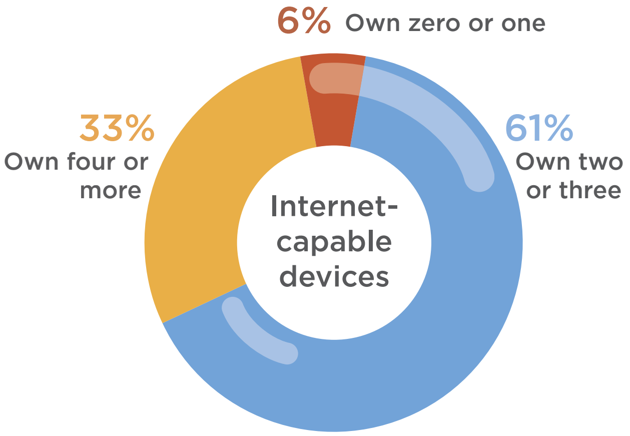
In 2016, ECAR collaborated with 183 institutions to collect responses from 71,641 undergraduate students about their technology experiences. The findings in this snapshot were developed using a representative sample of 10,000 students from 153 U.S. colleges and universities.

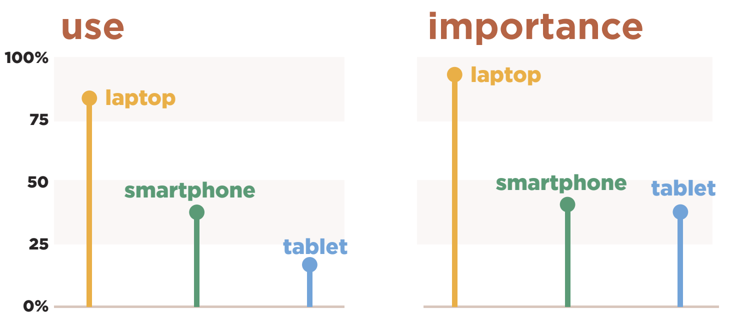
46% of students say they get more actively involved in courses that use technology.

78% of students agree that the use of technology contributes to the successful completion of courses.

TECHNOLOGY IS PERVASIVE IN THE LIVES OF STUDENTS:

90% of students own a smartphone and a laptop. Six in ten own a tablet.





Percentage of students who say they use the device in most or all of their courses

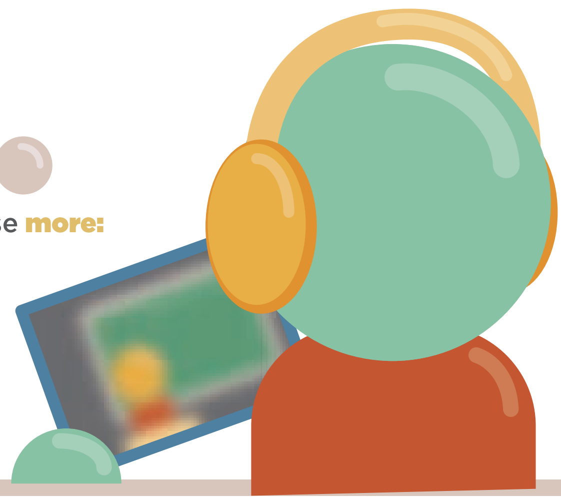
Percentage of device owners who say the device is very/extremely important to their academic success

LEARNING ENVIRONMENT AND ACADEMIC EXPERIENCES:

82% of students prefer a **blended learning environment.**

6 in 10 students say they want their instructors to use these **more:**

- Lecture capture
- Early-alert systems
- Free, web-based supplemental content
- Search tools to find references/information online for class work



EDUCAUSE Technology Research in the Academic Community studies track student and faculty experiences with technology to help IT leaders improve IT services and their delivery on campus.

TECHNOLOGY HAS CONSIDERABLE POTENTIAL TO ENGAGE STUDENTS IN CLASS:

Percentage of students who say that technology has helped them:

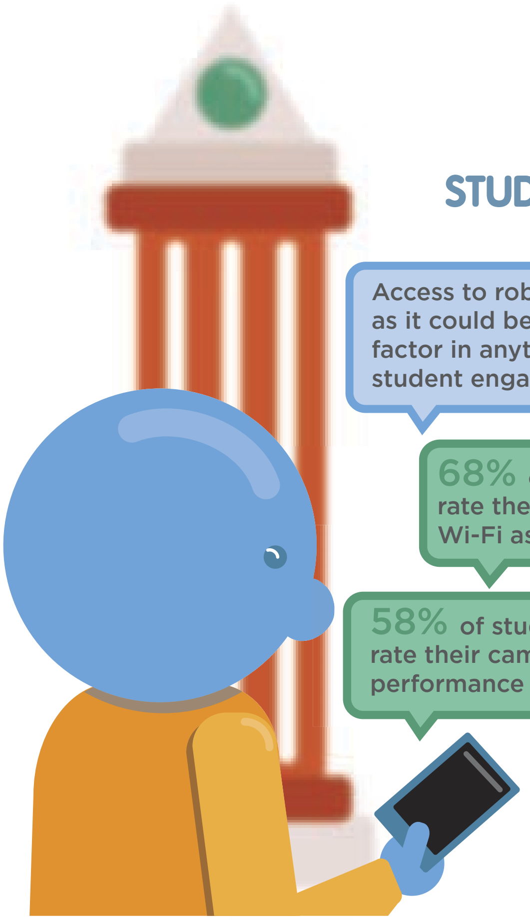
Ask instructors questions	79%
Engage in the learning process	71%
Work with other students on class projects	69%
Participate in group activities	65%

Many students report that faculty use technology in meaningful and engaging ways.

Percentage of students who say most or all of their instructors do these things:

- **57%** Encourage the use of online collaboration tools
- **61%** Use technology during class to make connections to the learning material
- **34%** Encourage the use of student devices during class to deepen learning
- **49%** Encourage the use of technology for creative or critical-thinking tasks

STUDENTS ARE ALWAYS CONNECTED:



Access to robust Wi-Fi is not as prevalent as it could be and might be a limiting factor in anytime, anyplace learning and student engagement activities.

68% of students rate the ease of login to campus Wi-Fi as good or excellent.

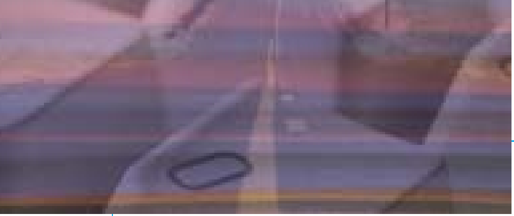
58% of students rate their campus Wi-Fi network performance as good or excellent.

2/3 of students typically connect two or more devices to the Internet at a time.

4 in 10 students say they get distracted in class by text messages, e-mail, social media, or web surfing.

ENHANCE DECISION MAKING WITH STUDENT DATA:

The EDUCAUSE Center for Analysis and Research conducts annual research to benchmark students' technology experiences and expectations. The research can catalyze conversations about IT services and their delivery, as well as the strategic uses of technology in support of the institutional mission. Institutions can participate for free and will receive the research report, an aggregate-level summary/benchmarking report, and the raw (anonymous) data of the institutions' responses. Read more about students and technology at http://www.educause.edu/ecar/about-ecar/technology-research-academic-community.



E-Learning, the Digital Divide, and Student Success at Community Colleges

The number of students who enroll in U.S. community colleges tends to be inversely related to the economy. When the economy is good and jobs are plentiful, potential (and enrolled) students may put off their education in order to work. When the economy is not strong and jobless rates are higher, students may take the opportunity to learn new skills and continue their education. So the community college enrollment decline that we are seeing across the United States is in part a result of this cyclical pattern. However, in a countertrend, community colleges have seen growth in the e-learning field. In fact, according to a 2015 national distance education survey: "eLearning enrollments have accounted for nearly all student enrollment growth at community colleges during the past eleven years."[1]

E-learning is an important option for community college students because they are more likely than four-year college/university students to be older, be working, have lower socioeconomic status, have dependents and hence more responsibilities outside of college, and require developmental education. Community colleges enroll more than 12 million students annually in credit and noncredit programs, and these students are very diverse. When we look at all undergraduate students in the United States, community college students are more likely than students at four-year institutions to be first generation, students of color, women, part-time students, and in a wider age range, from teens to senior adults.[2] Given the diversity of learners, community college faculty employ a wide variety of learning modalities, including e-learning, so access to electronic resources is important for the success of all of our students.

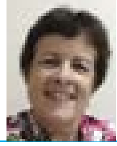
Research indicates that a "digital divide" remains in the United States despite rapid technological advances. One-third of low-income and rural K-12 students in the United States are unable to go online when at home. A national U.S. Department of Commerce study found that "only 55 percent of African American households and 56 percent of Hispanic households (compared with 74 percent of white households and 81 percent of Asian American households) and 58 percent of rural households (compared with 72 percent of urban households) had broadband Internet at home."[3] As noted, these populations are, historically, community college students. So as we contemplate the tremendous potential that technology offers, it only makes sense to do so in the context of our commitment to both access and completion.

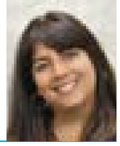
No one can predict either the future of technology or how a new future will change the teaching and learning processes. We can, however, discern trends, and increasing connections is one of the most important opportunities—if not *the* most important opportunity—provided by digital technologies. Another opportunity is more personalized learning. In a 2013 *EDUCAUSE Review* article, Rob Abel, Malcolm Brown, and Jack Suess pointed out that faculty today "have an unprecedented number of options among ways to plan, design, and execute a course, among ways to connect with and support learners, and among ways to situate learning in a wider variety of settings."[4] These varied ways for learning are exactly what large numbers of community college students are looking for. Our educational architecture is changing in response.

Community college faculty need to ensure that the promise of e-learning is a reality. Almost a third of all higher education faculty in the United States are community college faculty, and they teach nearly half of all U.S. undergraduate students.[5] Faculty work is changing in response to key influences such as the national focus on the role of community colleges in developing an educated workforce, more students transferring to baccalaureate-degree institutions, shifting student demographics and expectations, increasing accountability and the completion agenda, fiscal pressures and state-level disinvestment in public higher education, the concept of free public community college education,[6] and unprecedented technological change. In fact, Ray Kurzweil, former winner of the Lemelson-MIT Prize (the nation's largest invention and technological innovation award), predicted in 2008: "As prodigious and influential as information technology is already, we'll see a billionfold improvement in the next quarter century, and then we'll see it again."[7]

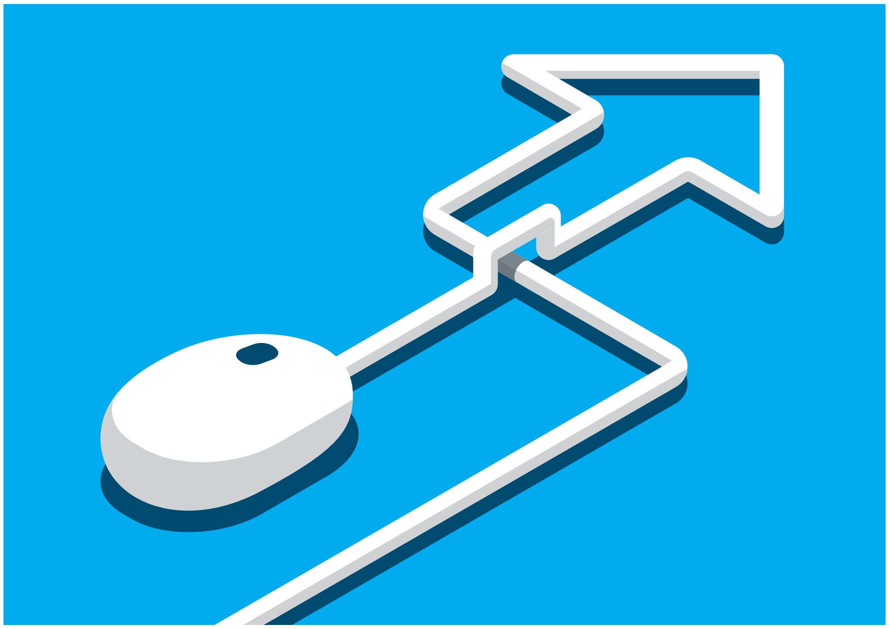
Faculty at the Maricopa Community Colleges, in the Phoenix metropolitan area, are working on ways to leverage digital resources, lower the cost of higher education, and support student access and success. Open educational resources (OER), through the Maricopa Millions OER Project, is one of these ways that electronic resources are being leveraged for student access, reduced cost of education, and integration with e-learning. The goal of the initiative is to radically decrease students' costs by offering "no cost" or "low cost" options for course materials. Courses designated as "no cost" will have no additional cost to the student beyond the fees associated with tuition. These might include, for example, OER-licensed online resources purchased by the college for student access. Courses designated as "low cost" will have required course materials that are under $40. These costs may be associated with copyrights for textbooks, printing of required materials, and/or online homework/quizzing systems.

Through the use of OER, the Maricopa Millions project has furthered the colleges' mission and increased opportunities for student success: reducing students' educational costs;





By SUSAN KATER, ROBERT SOZA, and LISA YOUNG



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expanding access to course materials by having them available on or before the first day of classes as well as throughout the course; providing faculty with the opportunity to customize the materials; and offering students an opportunity to contribute to course materials through open pedagogy, which enhances their engagement and likelihood of success. To date, Maricopa Millions has saved students nearly $6 million in course materials.

As the United States moves toward a "majority minority," the community college becomes more significant as an entry point for students from varied ethnic and socioeconomic backgrounds who are looking to continue their education, learn a new skill, or pursue special-interest courses. Their success is vital in supporting our communities' local and regional social and economic health. E-learning and the OER movement represent a significant opportunity for community colleges to bridge the digital divide and further student success. ■

Notes

1. Fred Lokken, *Trends in eLearning: Tracking the Impact of eLearning at Community Colleges,* 2015 Distance Education Survey Results (Washington, DC: Instructional Technology Council, 2016), 5.
2. American Association of Community Colleges, "Fast Facts," February 2016.
3. Cecilia Kang, "Bridging a Digital Divide That Leaves Schoolchildren Behind," *New York Times,* February 22, 2016; Shanna Smith Jaggars, "Democratization of Education for Whom? Online Learning and Educational Equity," *Diversity & Democracy* 17, no. 1 (winter 2014), citing U.S. Department of Commerce, Exploring the Digital Nation: America's Emerging Online Experience (2013).
4. Rob Abel, Malcolm Brown, and Jack Suess, "A New Architecture for Learning," *EDUCAUSE Review* 48, no. 5 (September/October 2013).
5. John S. Levin, "Understandings of Community Colleges in Need of Resuscitation: The Case of Community College Faculty," in *Understanding Community Colleges,* ed. John S. Levin and Susan T. Kater (New York, NY: Routledge, 2013); Tronie Rifkin, "Public Community College Faculty," American Association of Community Colleges website, [n.d.]; American Association of Community Colleges, "Fast Facts," February 2016.
6. For a perspective on "free," see David Monaghan and Sara Goldrick-Rab, "Is Community College Already Free?" Wisconsin Hope Lab, Policy Brief 16-01, January 20, 2016.
7. Ray Kurzweil, "Progress Accelerates Exponentially," in *The Way We Will Be 50 Years from Today: 60 of the World's Greatest Minds Share Their Visions of the Next Half-Century,* ed. Mike Wallace, (Nashville, TN: Thomas Nelson, 2008), 35.

Susan Kater is the Associate Vice Chancellor of Institutional Strategy for the Maricopa Community Colleges. **Robert Soza** is a residential English faculty member at Mesa Community College and the Maricopa Community Colleges Faculty Association President. **Lisa Young** is the Faculty Director of the Center for Teaching and Learning at Scottsdale Community College.

An Open Perspective on Interactive Textbooks

Textbooks are expensive. Open educational resources (OER) and open-source textbooks—textbooks that are licensed so that users can edit and reuse them—are a solution to the cost concern.

But there's more than money at stake. When an instructor assigns an open-source textbook on the syllabus, what does that say about learning? Compared with closed-source textbooks, open-source textbooks are better aligned with the values of academia, a community built on the free exchange of ideas. Colleges and universities are not only centers of learning but also generators of knowledge. Similarly, open-source textbooks are an invitation not only to read but also to contribute something new.

Tools like GitHub make it easy for faculty to collaboratively author open-source textbooks, but great content is only a part of great teaching. The progress made in developing open platforms must parallel the progress made in promoting open-source textbooks to ensure that the complete ecosystem around learning is aligned with the values of academia.

Not Just Price, but Pedagogy

The common complaint about commercial textbooks is cost. Between 2006 and 2016, college textbook prices increased by 73 percent.[1] That rise in prices took place contemporaneously with the enactment of the Higher Education Opportunity Act in 2008, which addressed textbook prices by, for instance, requiring price disclosures to professors. So despite legislation designed to reduce prices, commercial textbook prices remain high. And when high prices mean a student cannot afford the textbook, that student may fail the course, which is an even costlier problem.

This is why textbook cost is only a part of the story; the dream was never for cheaper textbooks but, rather, for student success. Instead of a question of textbook cost, the question is one of textbook *value*. Because if a commercial textbook—even a very expensive textbook—guaranteed good grades, wouldn't we all rush out to buy it?

But the price of learning isn't measured by money. It's measured by hard work: asking questions, making connections, refining knowledge. Learning is a generative and a community activity: working through tough problems in small groups. Perversely, commercial closed-source textbooks, regardless of their cost, reinforce many of the wrong attitudes toward learning: a closed-source textbook says that learning is about obeying authority, about reading rather than editing or writing, about assimilating the correct answer. And if you find that depressing, consider what a rented textbook says about learning.

Open for the Win

The opposite of the commercial closed-source textbook is the open-source textbook. Such textbooks fit into the broader category of OER, by which I mean any resource (including, for example, text, video, and interactive widgets) for teaching and learning released under a license that permits reuse. A Creative Commons license is the typical example. Warning: just because you pay nothing to view a resource does not mean that you can edit the resource.

Nevertheless, because they're low-cost or free, open-source textbooks address issues of affordability, accessibility, and equity. Moreover, because they are generally editable and reusable, open-source textbooks provide an opportunity to reinforce a constructivist understanding of learning. An open-source textbook is, after all, a textbook and thereby addresses the practical need for an expert, authoritative reference. And yet, it immediately calls that authority into question. Because it's editable, it invites students to reflect on their learning and on how the exposition could be improved and, ideally, to propose some specific edits. Like many open-source software projects, an open-source textbook allows users to file "bug reports." And because an open-source textbook is reusable, it permits other instructors to not only "adopt" the text but also "raise" the adopted text as if it were their own.

In short, open-source textbooks are aligned with the values we want to encourage about learning. We want both instructors and students to not only purchase but also take ownership of their educational resources. We want students to see knowledge not as a thing they receive but as something growing out of a community to which they contribute. There is no monetary price at which a closed-source textbook communicates those values.

Not Just Content, but Student Experience

The fight for open-source textbooks is only a proxy battle in a broader war over *pedagogical content knowledge*.[2] There's content knowledge (knowledge of "what" to teach) and pedagogical knowledge (knowledge of "how" to teach), but pedagogical content knowledge (PCK) is the knowledge of how to shape content to make it broadly accessible to learners. For instance, PCK

E-Content Editor: **Robert H. McDonald**

By JIM FOWLER

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includes an understanding of students' common misconceptions along with effective strategies for addressing them.

For an IT crowd, one useful metaphor is to think of PCK as user experience (UX). Content is certainly a part of UX, just as a teacher needs content knowledge. But UX is about how that content gets deployed to the user, just as PCK is about helping learners engage with content knowledge. In this analogy, pedagogical knowledge might be akin to knowing how to program, whereas PCK is knowing how to use programming skills to deliver great content.

Traditionally, the textbook is the reference for content knowledge, and PCK is that bridge that the teacher provides. But as the textbook becomes increasingly interactive, frequently paired with online homework systems and other computer-graded assessments providing rich feedback, the hope is that the interactive textbook could encompass both content knowledge and PCK. Such a book would be a boon for student success. This is the basic premise of adaptive learning technology.

In this scenario, however, who controls that platform? Faculty? Historically, feedback from students is what permits an instructor to iterate on his/her teaching; the same is true for digital resources. Mining student data is mining for PCK. Website analytics can lead to an understanding of where students get stuck in the text and, hopefully, can uncover which online activities are most effective at getting students unstuck—that's PCK. If the student data is held and analyzed by publishers, then publishers, rather than professors, will be masters of PCK.

Is that really a problem? I think so. When interactive textbooks are closed-source textbooks running on closed-source platforms, faculty may no longer understand how their own students are receiving formative feedback. As a result, those with the deepest content knowledge will be disconnected from the pedagogical feedback loop. These concerns are not so far off: already it can be challenging to perform a Quality Matters assessment when the key components of the course are behind publisher paywalls.

Creating Open Platforms for Open Content

Colleges and universities recognize their role as disseminators of content knowledge. Examples of university-level commitments to OER include the University of Minnesota's Open Textbook Library, Ohio State University's Affordable Learning Exchange, and Rice University's OpenStax. Even research groups are getting in the game, such as the American Institute of Mathematics with its Open Textbook Initiative. But in light of the concerns around PCK, we need open platforms to deploy that open content.

To fill this need, my team and I at Ohio State University designed Ximera, a system that serves interactive textbook content stored on GitHub and captures the resulting learner interactions with xAPI. GitHub provides a place for the many authors (and student contributors) to write the interactive, open-source text together. Git (the technology behind GitHub) makes it easy to collaborate on complicated documents. The open-source software community already understands how to use the Internet to collaboratively author "technical texts" (i.e., computer programs). Rather than trying to rediscover such a workflow, the community of educators should steal it. As digital textbooks encompass not only content but also how to teach that content, the textbook itself increasingly resembles software.

Storing OER on GitHub provides many spillover benefits. One key benefit of git is object permanence. Each version of the textbook is labeled with a commit hash, which provides an unambiguous way to refer to previous versions of the interactive textbook. To understand how updates to the text may affect how students' interact with the text, this history of all past versions is essential. Another benefit of git is "branches." With git we can be fixing typos in a student-facing version of the text (the "master branch") while also making wild experimental changes in a non-public version (the "development branch").

Conclusion

The significance of these open platforms is to put the best content-deployment system into the hands of the strongest content experts. Already at Ohio State, we've used this workflow to provide lower-cost interactive textbooks while also engaging more of our faculty and staff in the design of the textbook and other online pedagogical resources. It's a win for both our students and our instructional staff. ■

Notes

1. Ethan Senack and Robert Donoghue, *Covering the Cost: Why We Can No Longer Afford to Ignore High Textbook Prices* (Washington, DC: Student Public Interest Research Groups, 2016), executive summary.
2. See Lee S. Shulman, "Knowledge and Teaching: Foundations of the New Reform," *Harvard Educational Review* 57, no. 1 (spring 1987).

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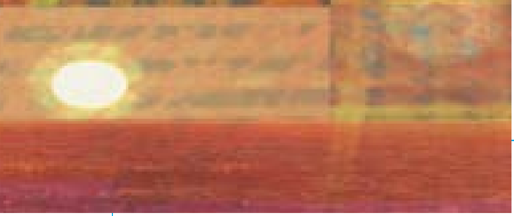

Reflecting on Learning Analytics

During his remarks at a ceremony commemorating the atomic bombings of Hiroshima and Nagasaki seventy-one years ago, U.S. President Obama contextualized the moment by saying: "Technological progress without an equivalent progress in human institutions can doom us."[1] Those of us working in higher education may not deal with the enormous global consequences of atomic weapons, but we do play powerful roles in helping our institutions appreciate the transformative effects, either positive or negative, of the technologies that we lead those institutions in adopting.

Many of us in the EDUCAUSE community have careers centered on examining—and helping colleagues consider ways of adapting—technologies so that they can be used to the greatest effect in teaching, learning, and research. Resistance to technological adoption can be rooted in fears of change, of technologies, or both. To some extent, our work entails engaging with colleagues to address concerns, both real and imagined, and to champion the adoption of new tools where justified. As institutional scouts in technological marketplaces, we have roles that also entail a deep understanding of our institutions' needs and a critical eye for separating the hype surrounding technological developments from the realistic uses. This is a cycle that frequently repeats itself in our field.

The ultimate measure of learning analytics systems should be the degree to which they improve the success of the students at our institutions.

Learning analytics tools represent a complicated iteration of this cycle. We will need to be on the top of our game in imagining future uses and also in engaging in informed critique.

At present, colleges and universities struggle mightily to improve learning environments and, more importantly, student success. A common, high-level measure of success is a graduation rate within 150 percent of the "normal" time for completion—that is, within six years for four-year institutions and within three years for two-year institutions. In the United States, that rate currently stands at a mere 60 percent for four-year and 31 percent for two-year institutions.[2] Nationally, a series of characteristics—such as institutional selectivity in admissions, race and ethnicity, socioeconomic status, and gender—are used to describe variations in these rates.

College and university leaders are increasingly trying to understand variations in graduation rates and the underlying causes. This is where learning analytics comes into the conversation. In what ways might the data relating to student characteristics and behaviors better inform the learning environments we design for our students? How might this data inform our students' choices? It is critical that we engage in systematic studies wherever possible. This is true not only for our students' sakes but also for the viability of our institutions. The stakes are high.

At best, analytic systems offer us the prospect of capturing data from student information systems, learning management systems, and other sources. With this data in hand, we have tools that promise to provide a means of identifying individual students who are struggling or institutional structures that do not serve their intended purposes. This idea motivates dedicated institutional leaders to adopt and invest in tools that fall under the category of *learning analytics.* So if we have data in hand and the means to analyze it, what is the problem?

Learning analytics discussions can be both fascinating and fraught, particularly to the extent that these tools do not clarify the algorithms or statistical models employed. This lack of transparency may be attributed to business models or to machine learning techniques. These techniques employ computational power not only in analyzing data but also in establishing the means by which the analysis takes place. In other words, one might end up with a list of students "at risk" but with no clear understanding of how exactly those students were identified. It is hard to overstate the degree to which this is a departure from established research methods, particularly in educational research. In contrast, it is much more common for those in the social sciences to specify statistical models based on findings in the literature or on hypotheses developed locally and then identify models with the greatest predictive power. This is a means of addressing issues of correlation or confounding variables that might otherwise lead to flawed analyses.

In terms of learning analytics, now is *not* the time for premature clarity. This is true whether that clarity takes the form of rejecting learning analytics tools for a lack of methodological familiarity or of accepting the product of these tools because they provide the comfort of actionable results, justified or not. Our role as information professionals is not to arbitrate these methodological debates but, rather, to make sure that

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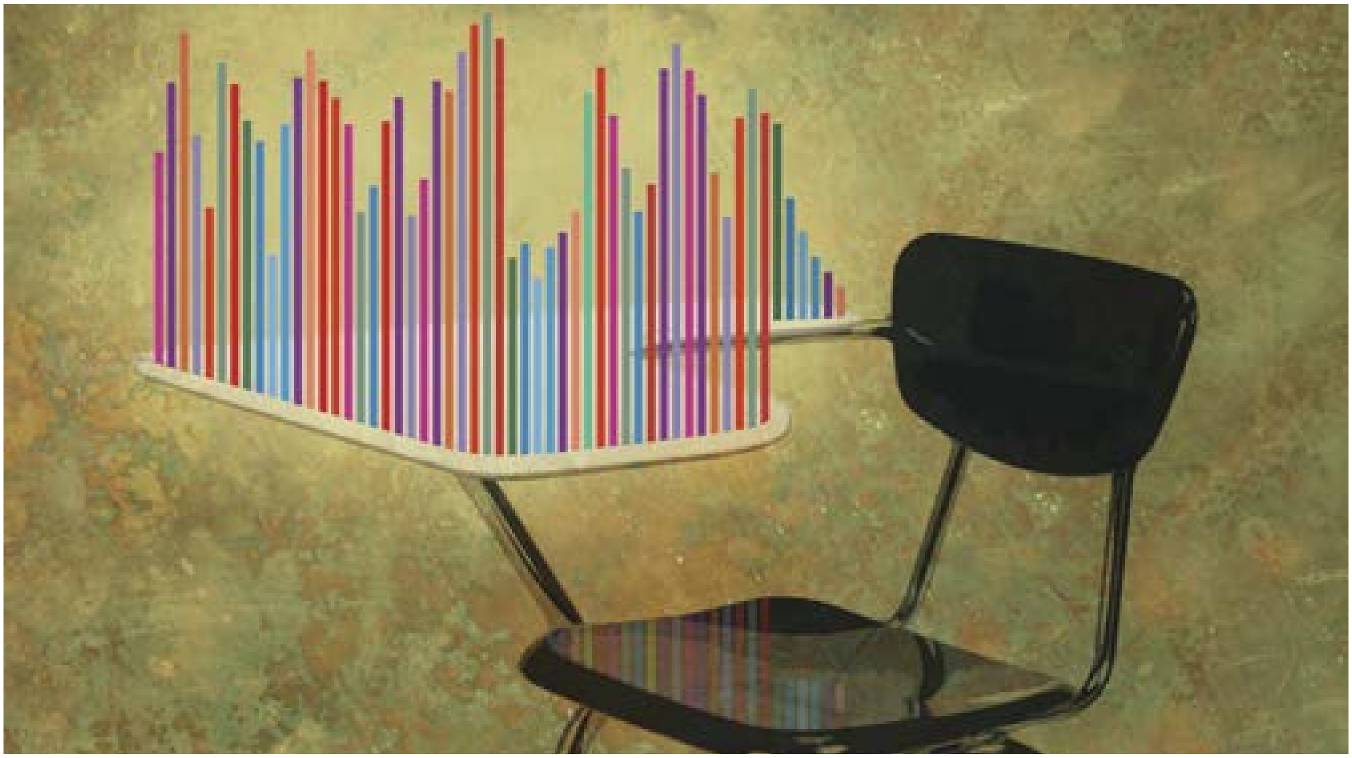
By **ANDREA LISA NIXON**



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significant institutional investments in learning analytics are warranted. This will entail marshaling the best thinking at our institutions. Unlike our colleagues in other sectors, those of us in higher education have the luxury of working with dedicated scholars who are both proponents and skeptics of the methods employed by analytics systems. As we engage in these debates, we need to judge success not on whether analyses are "actionable" but rather on whether the actions prompted actually improve student outcomes.

Fortunately there is important, emerging work that can inform our discussions. The NSF-funded Council for Big Data, Ethics, and Society (http://bdes.datasociety.net/)—led by danah boyd, Geoffrey Bowker, Kate Crawford, and Helen Nissenbaum—is a group of academic and industry researchers. The Council's work is broader in scope than learning analytics but promises to be of benefit insofar as it addresses methodological and ethical issues. The group's white paper "Perspectives on Big Data, Ethics, and Society" both enumerates policy gaps and identifies critical areas for further research.[3]

In addition, efforts are increasing to examine the resulting analyses in studies in which the methodological approaches are undisclosed. Anupam Datta, Shayak Sen, and Yair Zick of Carnegie Mellon University have developed a Quantitative Input Influence system designed to identify the degree of influence that input variables have on resulting outputs.[4] *ProPublica* made a notable contribution to critiquing a predictive analytics system used in judicial proceedings and shared the methods of its analysis.[5] These are both important models for examining unintended biases that may arise in algorithmically based decision making.

Technological leaders need to realize the potential effects, either positive or negative, of learning analytics. As we help our institutions navigate this situation, we should be prepared to draw on the strengths of both the proponents and the skeptics in our communities to ensure that institutional mechanisms are in place to examine the overall efficacy of learning analytics systems, as well as any unintended bias or other deficiencies that may creep into analyses. As always, the ultimate measure of these technological systems should be the degree to which they improve the success of the students at our institutions. As President Obama recognized, power lies in pairing technological progress and institutional development. ■

Notes

1. "Remarks by President Obama and Prime Minister Abe of Japan at Hiroshima Peace Memorial," May 27, 2016.
2. Grace Kena et al., *The Condition of Education 2016,* National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, May 2016.
3. Jacob Metcalf, Emily F. Keller, and danah boyd, "Perspectives on Big Data, Ethics, and Society," Council for Big Data, Ethics, and Society white paper, May 23, 2016.
4. Anupam Datta, Shayak Sen, and Yair Zick, "Algorithmic Transparency via Quantitative Input Influence: Theory and Experiments with Learning Systems," *Proceedings of 37th IEEE Symposium on Security and Privacy,* May 2016.
5. Julia Angwin et al., "Machine Bias," *ProPublica,* May 23, 2016.

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IT Educator: Not My Job?

During my time as a higher education CIO, there have been conversations in the profession regarding what the college/university president should know about technology. In my mind, this is also a conversation about whether or not the CIO is responsible for providing IT knowledge to the president. As I've thought about this debate, I've considered how the CIO, as the IT communicator and translator—that is, the IT educator—can best support the president and other members of the institution management team (IMT).

In most cases, a higher education institution does not exist to produce technology. It produces graduates who go on, ideally, to improve their own lives and our society. The institution may also be engaged in research, and some of that research may be IT-focused, but research isn't the only reason the institution exists. The president and the IMT are responsible for the leadership of the institution, but they cannot be knowledgeable about everything. If they were, why would they need the CIO? The president's job is to focus on strategy, not tactics. Presidents should be concerned with the "what"—not the "how"—in technology. The "how" is the CIO's job.

> **How can the CIO, as the IT communicator and translator—that is, the IT educator—best support the members of the institution management team?**

When I entered the CIO career field in the mid-1990s, some CIOs were feared by their colleagues, and even by their bosses, because the CIOs seemed to have some magic powers (or at least some secret information) that made them more powerful than the average employee. These CIOs could be arrogant and demeaning to the people they were supposed to serve. There have been a number of stereotypes and comedy sketches derived from this relationship between the IT leaders/departments and their customers. One of my favorites was Nick Burns, the computer guy. Nick was funny because he was over-the-top but also because the stereotype was very close to some realities. Nick would never explain the technology. He belittled the customer. However, real experiences like these resulted in a backlash that led many institutions to outsource the IT department or to bring in a leader from outside of the IT department.

During my almost two decades as a CIO in three industries and three higher education institutions, I've learned several things about the skills that are important for a CIO. In addition, I have conducted higher education CIO research over the past thirteen years. The Center for Higher Education CIO Studies (CHECS) research is conducted annually through a survey sent to higher education CIOs and a second, similar survey sent to the IMT members. This longitudinal research has revealed how thousands of CIOs and their colleagues/supervisors on the IMT feel about the CIO's skills and background. Beyond a doubt, communication is one of the most important skills for a CIO to have. And a critical aspect of communication skills is the ability to translate technology into everyday language. This translation helps the executive team and the president understand the possibilities and limitations of technology, without having to take an IT 101 class.

In my first CIO position, in a U.S. Air Force hospital, an encounter with a squadron commander (equivalent to a CEO) helped me grasp the reason CIOs are critical for an organization. The air force had produced a report on a hospital system that was having deployment problems. The report was sent to me, others, and the squadron commander. I found the report fascinating, and when I saw the squadron commander, I asked (with newbie enthusiasm): "Did you read this?" She looked at me, very seriously, and said: "No. That's why you are here." Before this encounter, I knew I was the IMT expert on technology, but this cemented my understanding of my role. The CIO helps the president and the IMT understand a very complex subject. Technology is important to most institutions, but again, it is not the reason the institution exists.

The CIOs from the CHECS 2016 CIO research agree. The CIOs and the IMT members are asked about the importance of various CIO roles and about the CIO's effectiveness in those roles. The CIOs rated the IT Educator role (i.e., evangelist for computer use and understanding; educator of employees regarding IT innovations bringing value to the organization) as important (3.6 on a scale of 1 to 5) and rated the CIOs as effective (3.37 on a scale of 1 to 5). The IMT members agreed with the CIOs, rating the IT Educator role 3.76 for importance and rating the CIO 3.43 for effectiveness. Even though the IT Educator was the sixth most important role according to both groups, it is important. Only 1 percent of the CIO respondents and 8 percent of the IMT respondents indicated that the IT Educator was *not the CIO's job.*

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By **WAYNE A. BROWN**

The CIOs and IMT members were also asked about the most important skills for a CIO to possess. According to the CIOs, this skill is communication. The IMT members selected communication as the second most important skill, following technical knowledge. Leadership was ranked second by the CIOs and third by the IMTs. Finally, the IMT respondents were asked about the CIO's effectiveness in four areas: communication skills; IT knowledge; political savvy; and strategic business knowledge (see table 1). Their opinions about these four CIO attributes were collected through a series of questions. The IMT responses were aggregated to create an average for each attribute. Communication skills ranked 3.54 on the 1 to 5 scale.

How can CIOs improve their communication skills? When I am giving a technology explanation to the president or to one of my IMT peers, I begin by going back to the basics. I determine who the audience is and what my purpose is for communicating. As IT professionals, we like to be precise. We don't want to oversimplify at the expense of accuracy. However, we need to keep in mind that we are not trying to turn non-IT executives into CIOs. We also tend to use technospeak. This is not a helpful practice: it can be irritating and often gets in the way of good communication. I have found that the best way to communicate with the president and the IMT about complex technology projects is to translate the information into everyday language, use examples that are not technology-related, and bring humor to the conversation.

One example is open source software (OSS). Many non-IT executives think it is free. To install OSS, all we need to do is flip on a switch, and we will be off and running without all those big vendor license costs. My explanation of OSS for the non-IT executive is that OSS is "free" like puppies, not like beer. These few words generate a picture that is not threatening, may be funny, and gets the point across that care and feeding will have to be bought for our new puppy, OSS.

Another option is to use the "a picture is worth a thousand words" approach. I worked as a CIO for a college that had insufficient bandwidth from its wide area network (WAN) to the Internet. I had to approach the president for unbudgeted funding to improve this network. I asked one of the network leaders for a picture of the problem. The picture I received was a very accurate and detailed picture of the WAN, including IP addresses and lots of Visio symbols. I turned this into a picture of a large pipe from the WAN into a tiny pipe out to the Internet. The president immediately understood the problem and funded the improvements. The network leader, on the other hand, was very concerned that the picture was not literally accurate. But we have to keep *the goal* of communication in mind. The president did not want to rearchitect the network; he needed to understand the problem so that he could make a decision about an unbudgeted request.

CIOs are not the only ones who are expected to serve as the expert for their respective areas. The vice president for each area of an institution represents the expert for that area at an executive level. For example, when I need to get an understanding of how generally accepted accounting principles (GAAP) impact cloud services, the CFO doesn't tell me to look it up. He/she patiently gives me a lesson on capital-versus-expense costs and on how those costs are treated in accounting. Similarly, the marketing and admissions vice president doesn't send me to Wikipedia when I am trying to grasp the enrollment "funnel"; he/she draws me a picture and explains the parts and potential leakage.

TABLE 1. CIO ATTRIBUTES AND EXAMPLES

ATTRIBUTE	EXAMPLES
Communication Skills	Fluent in business language Fluent in higher education language Able to communicate and present information without technical terms to non-technical people
IT Knowledge	Understands how IT is applied in the organization Able to use current IT resources to fill institutional requirements Uses new technology for the institution Familiar with the acquisition of IT
Political Savvy	Able to assess situations that might be confrontational and act tactfully Able to work well with a majority of people
Strategic Business Knowledge	Knowledge of institutional offerings Understanding of market and business processes Familiar with the competition

If the president can't rely on a VP for expertise in an area, then why have the VP? CIOs are responsible for translating technology into everyday language and communicating the benefits and limitations of technology to the president and other members of the IMT. If we don't do it, who will? Serving as the IT educator *is* our job as CIOs. ■

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