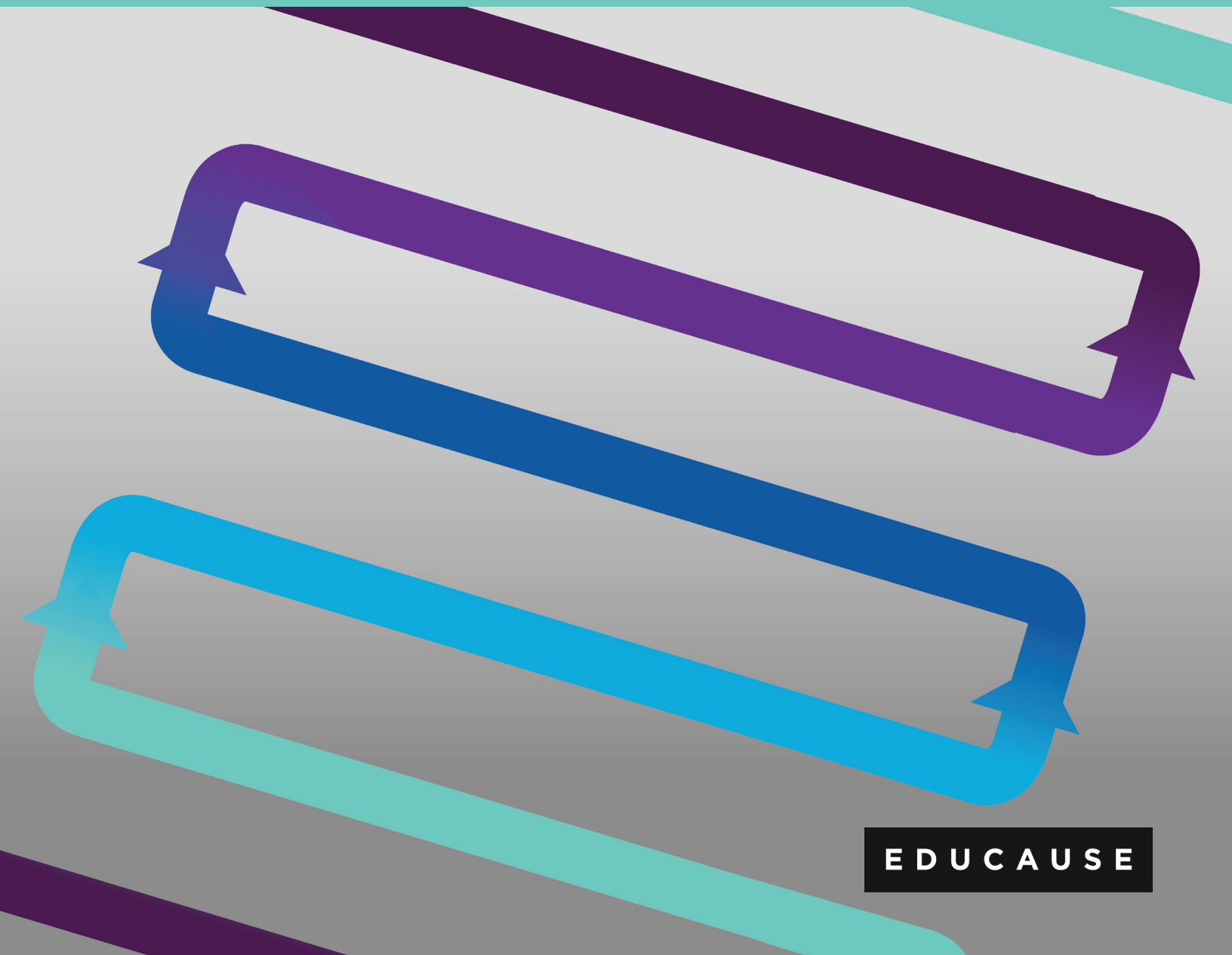
EDUCAUSE CENTER FOR ANALYSIS AND RESEARCH

# Higher Education's 2018 Trend Watch and Top 10 Strategic Technologies



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EDUCAUSE is a higher education technology association and the largest community of IT leaders and professionals committed to advancing higher education. Technology, IT roles and responsibilities, and higher education are dynamically changing. Formed in 1998, EDUCAUSE supports those who lead, manage, and use information technology to anticipate and adapt to these changes, advancing strategic IT decision making at every level within higher education. EDUCAUSE is a global nonprofit organization whose members include U.S. and international higher education institutions, corporations, not-for-profit organizations, and K–12 institutions. With a community of more than 99,000 individuals at member organizations located around the world, EDUCAUSE encourages diversity in perspective, opinion, and representation. For more information please visit educause.edu.

## Introduction and Overview

The 2018 EDUCAUSE Top 10 IT Issues list shows how digital technology is remaking higher education through four key themes: institutional adaptiveness, improved student outcomes, improved decision-making, and IT adaptiveness. The Top 10 IT Issues are those that members have identified as the most strategic IT-related issues at their institutions. Behind these issues lie the new technology investments organizations are considering or actively planning, as well as the external trends influencing IT strategy.

Listening to the media, bloggers, and many thought influencers, one gets the impression that we are living the stuff of science fiction, with voice-activated (and soon thought-activated) digital assistants and advisors that can drive our cars, run our homes, and manage our lives; security threats that can destroy fortunes and careers and topple governments; and technology-facilitated education and healthcare that have the potential to elevate the lives of even the poorest and most remote. It's exciting and terrifying and astonishing to have seemingly advanced a century in less than a generation. At the same time, our world is filled with political and social uncertainty, with enough progress to comfort optimists and enough impending catastrophe to sustain pessimists. How many in 1998 predicted 2018's advances, disasters, and divisions?[1] Would you have believed them?

By no means has the ivory tower remained unassailed. Political and social unrest are unsettling our campuses, our professions, our business model, and our values. Technology is contributing to our sector's transformation, in ways that are beneficial, destructive, and, perhaps mostly, unpredictable. Change is here, not just for a time, but as a new member of the family, welcome or not.

What to do, and where to pay attention? Some technologies are unripe, overhyped, or not broadly relevant. Some trends cannot be ignored, but others can be disregarded for now. Other than asking peers, how does a technology or campus leader know where to focus? For focus we must, if we are to accomplish anything within our means. This report provides some grounding perspective, by identifying the more-widespread trends and the new technologies and by suggesting what the coming years might bring.

The EDUCAUSE trend watch and strategic technologies research identifies these underlying trends and technologies and maps them to the Top 10 IT Issues for a consolidated view to help institutions plan and manage their technology investments and services and devise and support a strategic approach. The issues, trends, and strategic technologies were all identified via an EDUCAUSE survey in the summer of 2017. For a complete listing of all the trends and technologies we surveyed, please consult the definitions section (page 23).

Since 2014, EDUCAUSE has examined higher education's top strategic technology priorities and the trends associated with those technologies. This year the popular Top 10 Strategic Technologies report and the Trend Watch report are being combined into one report for a full view of the widespread trends and technologies influencing higher education. In addition, EDUCAUSE will publish a separate report examining in detail the nine different technology domains we asked about and reviewing each domain's component technologies and the trends associated with those technologies. You can find all of the 2018 trends and technologies research online.

This report focuses on the widespread trends and emerging technologies influencing higher education institutions. Trends are pervasive external factors that influence institutional and IT strategy and often shape the adoption of technologies. This report examines the trends that institutions are paying the most attention to and that are influencing emerging institutional IT strategy the most. This year's trend list included 39 items.

Technologies are what IT organizations *do*. Mature, commonly deployed technologies (such as financial information systems or networks) may be among the most mission-critical technologies, but they are generally more likely to receive operational than strategic attention.[2] Strategic technologies, by contrast, are the relatively new technologies institutions will be spending the most time implementing, planning for, and tracking in 2018. None of the 73 technologies analyzed in this research is currently in place in more than 30% of institutions.

## Summary

- The five trends exerting the most influence on higher education's IT strategy are (1) complexity of security threats, (2) student success focus/imperatives, (3) data-driven decision-making, (4) contributions of IT to institutional operational excellence, and (5) increasing complexity of technology, architecture, and data. Each of these trends is influential at 61% or more of colleges and universities.
- Many much-discussed trends have yet to become influential for most institutions' technology strategy. They include digitization and changes in the fundamental activities of education, research, and administration that would truly reshape higher education. Yet a minority, and in some cases a large minority, of institutions are incorporating these trends into their IT strategy.
- The top 10 strategic technologies are characterized by technologies that will facilitate student success, teaching and learning, and moving to the cloud.
- Doctoral institutions are investing more effort into their particular strategic technologies than other types of institutions.
- Digital microcredentials (including badging) and privacy-enhancing technologies (e.g., limited-disclosure technologies, anonymous credentials) are among the most-tracked technologies in 2018, a sign of potential future directions.

Collectively, the 2018 top trends and strategic technologies support the four major themes of the Top 10 IT Issues—institutional adaptiveness, improved student outcomes, improved decision-making, and IT adaptiveness. We advise institutions to consider the trends and technologies in the context of the Top 10 IT Issues, and we provide a mapping to facilitate institutional conversations and planning.

## Trend Watch 2018

This is the fourth year that EDUCAUSE has tracked the influence of major trends on the IT strategy of colleges and universities. Some trends, such as complexity of security threats and the Internet of Things, are technology trends. But we also track environmental trends—such as diversity, equity, and inclusion or changing faculty roles—that can influence institutional priorities and directions, which, in turn, influence technology strategy. Our research has moved from tracking 15 trends (2015), to 29 (2016), to 36 (2017), to 39 in 2018. We assessed the trends presented in this report via an EDUCAUSE survey in the summer of 2017. The influence of the trends that we studied this year ranged widely (see figure 1), with some affecting as many as 3 in 4 institutions, and others as few as 1 in 20. To help readers focus their attention, we divide the trends into four groupings, according to the impact they are having across institutions: most influential, taking hold, worth understanding, and limited impact.

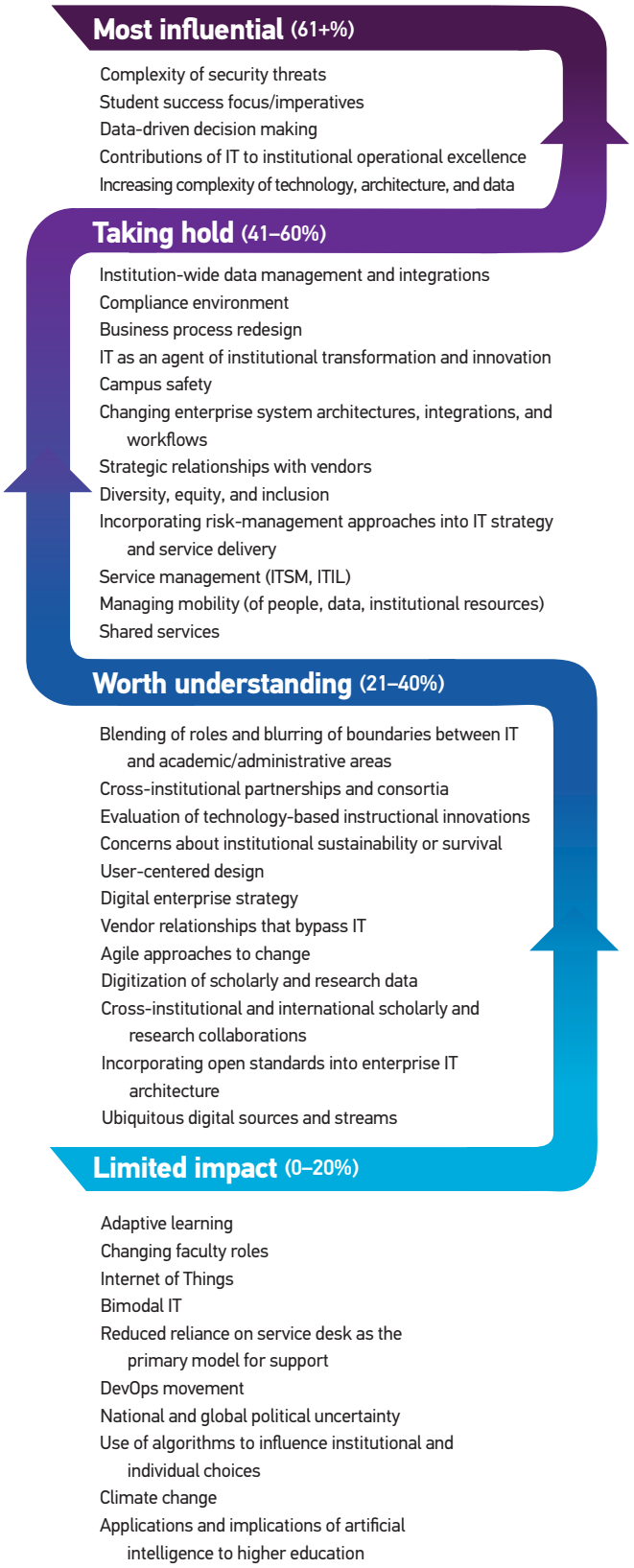


**Figure 1. Trends and their influence on IT strategy**

### Understand how the most influential trends are affecting your institution.

Five trends are influential at 61% or more of colleges and universities (listed below from highest to lowest level of influence):

- Complexity of security threats
- Student success focus/imperatives
- Data-driven decision-making
- Contributions of IT to institutional operational excellence
- Increasing complexity of technology, architecture, and data

### Review the trends that are taking hold and address them at your institution.

Twelve trends are influential at 41–60% of institutions (listed below from highest to lowest level of influence):

- Institution-wide data management and integrations
- Compliance environment
- Business process redesign
- IT as an agent of institutional transformation and innovation
- Campus safety
- Changing enterprise system architectures, integrations, and workflows
- Strategic relationships with vendors
- Diversity, equity, and inclusion
- Incorporating risk-management approaches into IT strategy and service delivery
- Service management (ITSM, ITIL)
- Managing mobility (of people, data, institutional resources)
- Shared services

### Understand these trends, and consider their possible role at your institution.

The influence of 12 trends is limited to no more than 40% of institutions (listed below from highest to lowest level of influence):

- Blending of roles and blurring of boundaries between IT and academic/administrative areas
- Cross-institutional partnerships and consortia
- Evaluation of technology-based instructional innovations
- Concerns about institutional sustainability or survival
- User-centered design
- Digital enterprise strategy
- Vendor relationships that bypass IT
- Agile approaches to change
- Digitization of scholarly and research data
- Cross-institutional and international scholarly and research collaborations
- Incorporating open standards into enterprise IT architecture
- Ubiquitous digital sources and streams

### The remaining 10 trends were of limited impact in our research.

- Adaptive learning
- Changing faculty roles
- Internet of Things
- Bimodal IT
- Reduced reliance on service desk as the primary model for support
- DevOps movement
- National and global political uncertainty
- Use of algorithms to influence institutional and individual choices
- Climate change
- Applications and implications of artificial intelligence to higher education

## The Top 10 Strategic Technologies for 2018

The top 10 strategic technologies for 2018 were identified from a list of 73 technologies. Numbers in parentheses are the 2017 rankings for technologies in last year's top 10. Because of a tie for the 10th spot, this year's list includes 11 technologies.

1. Uses of APIs *(3; tie)*
2. Active learning classrooms *(1)*
3. Incorporation of mobile devices in teaching and learning *(3; tie)*
4. Mobile apps for enterprise applications *(5)*
5. Technologies for improving analysis of student data *(2)*
6. Technologies for planning and mapping student educational plans *(7)*
7. Blended data center (on premises and cloud based) *(6)*
8. Predictive analytics for student success (institutional level)*
9. Database encryption *(8)*
10. (tie) IT asset management tools (e.g., CMDB)
10. (tie) Student success planning systems[3]

**This technology was new in the 2018 survey.*

### Top 10 Strategic Technology Descriptions

1. **Uses of APIs:** An API defines how a system interacts with other systems and how data can be shared and manipulated across programs. A good set of APIs is like building blocks that allow developers to more easily use data and technologies from various programs. APIs are used in many ways in higher education—for example, to pull data from the student information system into the learning management system, to integrate cloud-based with on-premises services, as an approach to security, and to access web-based resources.
2. **Active learning classrooms:** Active learning classrooms (ALCs) are student-centered, technology-rich learning environments designed on the principles of active pedagogical approaches. ALCs typically feature movable furniture, large displays, projectors, and other tools that support active learning.
3. **Incorporation of mobile devices in teaching and learning:** Mobile devices integrated into courses can be used for course assignments, field work, collaboration, and other activities. Such integration includes

ensuring that course content functions well on mobile devices, as well as leveraging the unique capabilities of mobile devices for learning.

4. **Mobile apps for enterprise applications:** Mobile apps for enterprise applications refers to web-based applications that run on mobile devices and are designed to integrate with all aspects of an organization's businesses and processes. These apps make it possible to access enterprise-wide resources (such as course catalogs, student information systems, and human resource systems) and conduct enterprise transactions from mobile devices.
5. **Technologies for improving analysis of student data:** These technologies enable immediate access to and rapid analysis of large, complex data sets, making it possible to discern trends in student engagement, in the types of difficulties students are encountering, and in the likelihood of success in attaining credentials across the student body.
6. **Technologies for planning and mapping student educational plans:** Educational planning tools allow students and advisors to work together to build customized pathways through the curriculum that are appropriate for each individual's interests and goals. In addition, these technologies offer a reliable way to chart and track progress toward a degree or credential. They also support institutions in the development of schedules that match demand.
7. **Blended data center (on premises and cloud based):** As institutions move services to the cloud, they usually move into a blended environment where they continue to maintain an on-premises data center while also managing a set of services that may run the gamut from software as a service to infrastructure as a service. While cloud-based solutions offer advantages related to agility, performance, and scalability, the blended environment requires a shift in strategy to one that encompasses both environments.
8. **Predictive analytics for student success (institutional level):** Predictive analytics for student success is the statistical analysis of massive amounts of data to create models that establish risk factors relating to student persistence, retention, and completion. These models enable proactive institutional support of student success.
9. **Database encryption:** Database encryption is the process of encrypting data within a database so that the data are rendered unreadable without the decryption key. Often suggested as a way to protect sensitive data, database encryption can be costly and requires more storage space than a nonencrypted database.

10. (tie) **IT asset management tools (e.g., CMDB):** IT asset management tools provide an account of the significant components of the IT environment, including dependencies and life cycles. As IT assets expand beyond central IT, both on campus and in the cloud, asset management becomes more complex. IT asset management tools can help institutions better understand, plan for, and make decisions about the resulting technology mix.
10. (tie) **Student success planning systems:** Student success planning systems aggregate a broad range of academic, learning, financial, and other data, enabling personnel throughout the institution to collaborate in support of retention and completion.

## Institutional Differences

The top 10 strategic technologies were identified from a list of 73 technologies. Each technology was assigned an "attention" score that was a weighted combination of intentions to plan for, track, or implement a technology in 2018 (see the Methodology section for more details). The top 10 were the 10 technologies with the highest attention scores. We tested for statistically significant institutional differences in attention scores by three variables:

- **Carnegie Classification:** Associate's, bachelor's, public master's, private master's, public doctoral, private doctoral, other US, and non-US.
- **Institutional size:** Fewer than 2,000 FTEs (students), 2,000–3,999 FTEs, 4,000–7,999 FTEs, 8,000–14,999 FTEs, and 15,000+FTEs.
- **Institutional approach to technology adoption:** Early (before other institutions), mainstream (about the same time as peer institutions), and late (after peer institutions). Early adopters accounted for 38% of respondents, mainstream 44%, and late adopters 19%.

We found institutional differences for 7 of the 11 technologies in the list (see figure 2). Generally, large and public institutions are devoting more attention than smaller and private institutions. Figure 3 offers a summary view of the top 10 strategic technologies by Carnegie class. Each type of institution is focusing on a somewhat different set of new technologies and at a somewhat different pace. Public doctoral institutions are investing more effort into active learning classrooms than those in other Carnegie classes and non-US institutions. Every institutional type is devoting significant time to uses of APIs, although public master's institutions are moving more slowly. Associate's institutions are unique in their focus on open educational resources and e-signature technologies.

Doctoral institutions are investing more effort into their particular strategic technologies than other types of institutions. In 2017, bachelor's institutions stood out as investing the least of all institutional types, but this year their level of effort across their top 10 portfolio is similar to that of most of the other institutional types.

| | Devoting more attention than others | Devoting less attention |
|---|---|---|
| **Active learning classrooms** | • Public doctorals<br>• 4,000–7,999 FTE<br>• 15,000+ FTE | • Associate's<br>• Non-US<br>• Less than 2,000 FTE<br>• 8,000–14,999 FTE |
| **Mobile apps for enterprise applications** | • 2,000–3,999 FTE<br>• 8,000–14,999 FTE | • Less than 2,000 FTE<br>• 4,000–7,999 FTE<br>• Late technology adopters |
| **Technologies for improving analysis of student data** | • Public master's<br>• Public doctorals<br>• 4,000–7,999 FTE<br>• 8,000–14,999 FTE | • Bachelor's<br>• Non-US<br>• Less than 2,000 FTE<br>• 2,000–3,999 FTE |
| **Technologies for planning and mapping student educational plans** | | • Private doctorals<br>• Non-US |
| **Predictive analytics for student success (institutional level)** | | • Late technology adopters |
| **Student success planning systems** | • Public doctorals | • Private master's<br>• Private doctorals<br>• Non-US |
| **IT asset management tools (e.g., CMDB)** | • Private doctorals | • Associate's<br>• Private master's<br>• Non-US |

**Figure 2. Institutional differences in attention to the strategic technologies**

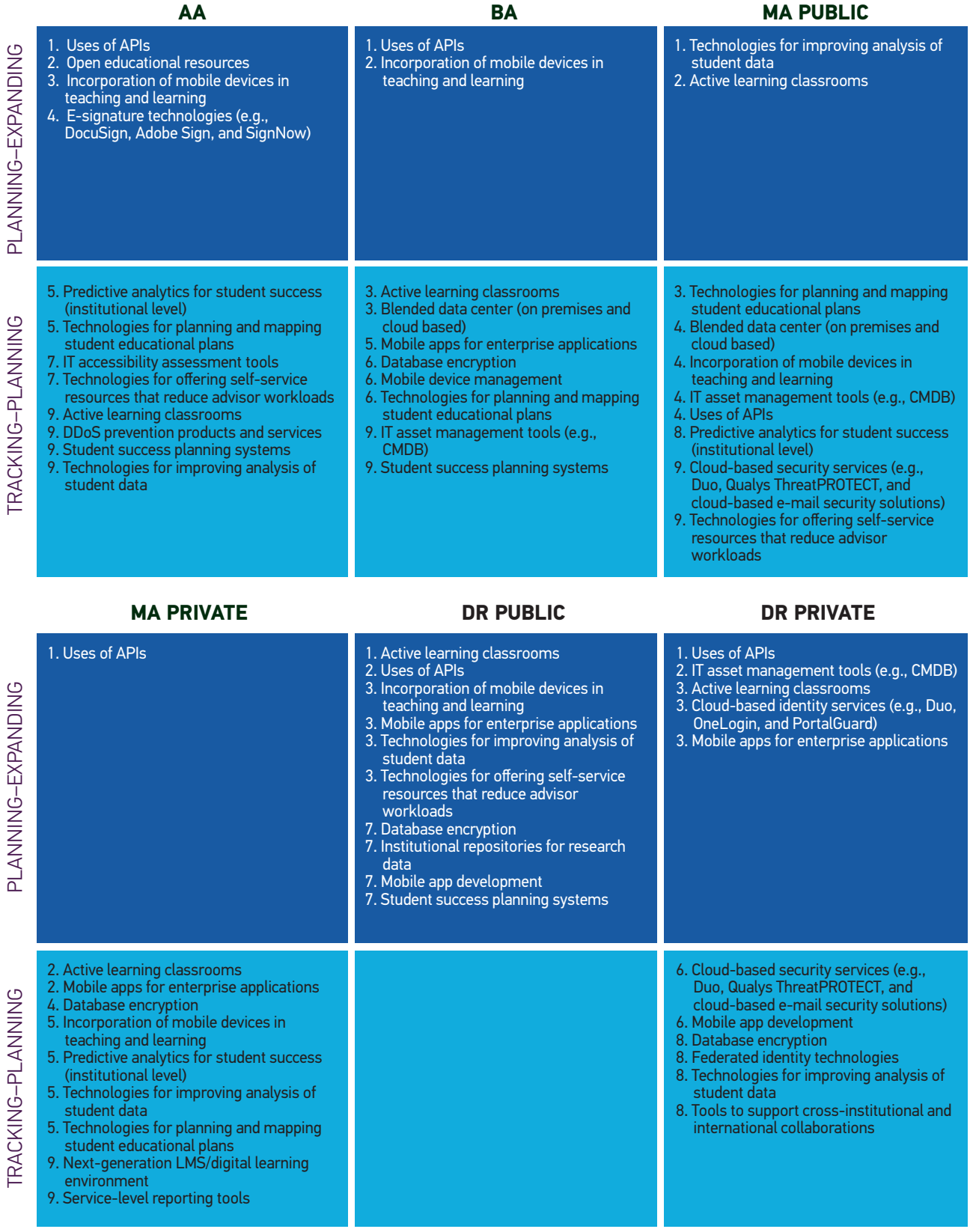


**Figure 3. Top 10 strategic technologies, by Carnegie class**

## Where Are We Headed and How Fast?

What do these data tell us about the kind of progress higher education might make with the technologies measured in this study? We used institutions' 2018 intentions for implementing and planning technologies to estimate deployment of all 73 technologies within roughly two years (2019–20) and five years (2021–23). We used the following categories to group estimates for when each technology is expected to be:

- **Experimental** (deployed institution-wide in 20% or fewer institutions)
- **Emergent** (deployed institution-wide in 21–40% of institutions)
- **Growing** (deployed institution-wide in 41–60% of institutions)
- **Mainstream** (deployed institution-wide in 61–80% of institutions)
- **Universal** (deployed institution-wide in 81–100% of institutions)

The 2017 top 10 strategic technologies list included 8 of the 11 technologies on this year's list, enabling us to compare our 2017 predicted pace of adoption with actual progress. Higher education, perhaps predictably, is not moving as quickly as our estimates suggested. We predicted that uses of APIs, active learning classrooms, and mobile apps for enterprise applications would all achieve growing adoption by the end of 2019, yet all are still at the experimental level (see figure 4). Next year's research will afford us the opportunity to finalize our comparison for these three technologies, at least.

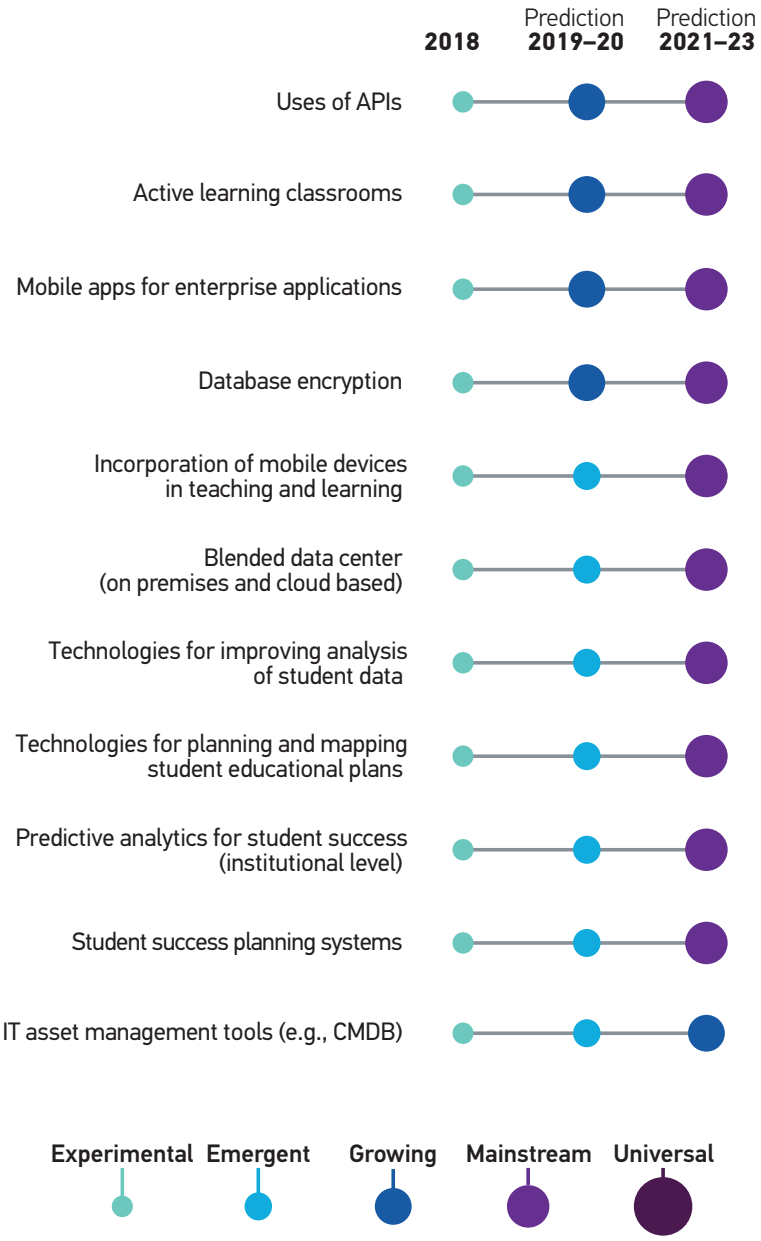


**Figure 4. Strategic technologies adoption trends**

## Up and Coming

Knowing which technologies institutions are most commonly tracking can provide a preview into the future. We found a distinction between technology planning and implementation versus technology tracking: None of the technologies institutions are most commonly tracking made the overall top 10 list. Four of the possibly up-and-coming technologies listed below were also on last year's list: next-generation LMS, end-to-end communications encryption, privacy-enhancing technologies, and adaptive learning. Next-generation LMS and adaptive learning were also among the most widely tracked 2016 technologies. One of the technologies on last year's up-and-coming list made this year's top 10 list: database encryption.

At least 30% of institutions are tracking these 15 technologies in 2018:

- Next-generation Wi-Fi (e.g., 802 11ah, HaLow) (42%)
- Integration platform as a service (37%)
- Next-generation LMS/digital learning environment (36%)
- Content-aware data loss prevention (34%)
- Software-defined networks (34%)
- End-to-end communications encryption (33%)
- Digital microcredentials (including badging) (32%)
- Privacy-enhancing technologies (e.g., limited-disclosure technologies, anonymous credentials) (32%)
- Adaptive learning (31%)
- Predictive learning analytics (course level) (31%)
- Applications of analytics to security (such as user behavioral analytics) (30%)
- Cloud access security broker (30%)
- Games and gamification (30%)
- High-precision location-sensing technologies (30%)
- Mobile apps for institutional BI/analytics (30%)

## Implications: Knitting Together the Top 10 IT Issues, Strategic Technologies, and Trends

The list of the top trends and top strategic technologies can inform—but should not substitute for—a strategic plan or roadmap. IT leaders and professionals should always ensure that institutional strategy drives IT strategy and that IT strategy and architecture drive technology decisions.

To help readers act on these findings, we mapped the top 10 strategic technologies and both the trends that are most influential and those that are taking hold to the Top 10 IT Issues. Table 1 summarizes the four major themes of the Top 10 IT issues—institutional adaptiveness, improved student outcomes, improved decision-making, and IT adaptiveness—and the individual IT issues, trends, and strategic technologies that most pertain to those themes. Consider conversations and planning sessions for each of the four themes, and explore the extent to which overall major trends and emerging technologies are playing out at your institution.

**Table 1. Matrix of issues, trends, and technologies**

| Top 10 IT Issues Theme | IT Issues | Trends | Strategic Technologies |
|---|---|---|---|
| **Institutional Adaptiveness**<br>Institutional and IT leaders are strengthening their individual and collective capacity not only for effective and efficient but also for consequential uses of technology. | 3. **Institution-wide IT strategy:** Repositioning or reinforcing the role of IT leadership as an integral strategic partner of institutional leadership in achieving institutional missions<br>6. **Higher education affordability:** Balancing and rightsizing IT priorities and budget to support IT-enabled institutional efficiencies and innovations in the context of institutional funding realities<br>10. **Change leadership:** Helping institutional constituents (including the IT staff) adapt to the increasing pace of technology change | • Contributions of IT to institutional operational excellence<br>• Business process redesign<br>• IT as an agent of institutional transformation and innovation<br>• Shared services | |

| Top 10 IT Issues Theme | IT Issues | Trends | Strategic Technologies |
|---|---|---|---|
| **Improved Student Outcomes**<br>Work on student success initiatives has become both more tactical (with a nuts-and-bolts focus on integrations) and more aspirational (with a new emphasis on students' entire experience with the institution). | 2. **Student success:** Managing the system implementations and integrations that support multiple student success initiatives<br>5. **Student-centered institution:** Understanding and advancing technology's role in defining the student experience on campus (from applicants to alumni) | • Student success focus/ imperatives | 2. Active learning classrooms<br>3. Incorporation of mobile devices in teaching and learning<br>6. Technologies for planning and mapping student educational plans<br>8. Predictive analytics for student success (institutional level)<br>10. Student success planning systems |
| **Improved Decision-Making**<br>The data issue is every bit as complicated as has been predicted, and efforts to gather, manage, and use the data are advancing. | 4. **Data-enabled institutional culture:** Using BI and analytics to inform the broad conversation and answer big questions<br>8. (tie) **Data management and governance:** Implementing effective institutional data governance practices<br>8. (tie) **Digital integrations:** Ensuring system interoperability, scalability, and extensibility, as well as data integrity, standards, and governance, across multiple applications and platforms | • Data-driven decision making<br>• Institution-wide data management and integrations<br>• Changing enterprise system architectures, integrations, and workflows | 1. Uses of APIs<br>5. Technologies for improving analysis of student data<br>8. Predictive analytics for student success (institutional level) |
| **IT Adaptiveness**<br>IT organizations are adapting themselves to new economic, demographic, and industry models and realities and are addressing the information security of the institution with even greater rigor. | 1. **Information security:** Developing a risk-based security strategy that keeps pace with security threats and challenges<br>7. **IT staffing and organizational models:** Ensuring adequate staffing capacity and staff retention in the face of retirements, new sourcing models, growing external competition, rising salaries, and the demands of technology initiatives on both IT and non-IT staff | • Increasing complexity of technology, architecture, and data<br>• Complexity of security threats<br>• Compliance environment<br>• Strategic relationships with vendors<br>• Campus safety<br>• Diversity, equity, and inclusion<br>• Incorporating risk-management approaches into IT strategy and service delivery<br>• Service management (ITSM, ITIL)<br>• Managing mobility (of people, data, institutional resources) | 4. Mobile apps for enterprise applications<br>7. Blended data center (on premises and cloud based)<br>9. Database encryption<br>10. IT asset management tools (e.g., CMDB) |

### Learn

Where are your—or your colleagues' or staff's—learning gaps among these technologies and trends? Some gaps matter more than others. Lean on EDUCAUSE resources, communities, and events to come up to speed and help educate those around you.

### Plan

Planning is the foundation for good execution. Be sure you have such basics in place as a roadmap, enterprise architecture, and IT governance. Some technologies in this report may be highly relevant but may require other, more foundational technologies. Pace and sequence your investments carefully to avoid costly mistakes.

Don't forget the broader environment in which you operate. Be aware of trends and consciously incorporate the most important into your IT strategy.

Use the EDUCAUSE Core Data Service to compare your progress with that of peer institutions and to find peers to learn from and possibly collaborate with. Get advice via EDUCAUSE Constituent Groups and at events.

### Do

Implement your IT strategy, paying careful attention each year to changing trends, technologies, and IT issues that may require adjustments or revisions to the strategy. As you meet your major milestones, communicate your successes to institutional leadership and to your staff. Celebrate your successes and learn from setbacks to continue forward momentum.

As your strategy matures, champion a new EDUCAUSE working group to work with peers to plan and design best practices and implementation guidelines.

### Share

Share what you know broadly across your institution. Help your staff come up to speed and gain perspective beyond their individual functions. Advance your influence by helping institutional leaders develop a realistic and hopeful vision for technology that will support institutional strategy and help achieve institutional ambitions.

If you are among the leading institutions in one or more areas, share your expertise and experience to help advance the entire field. Write articles or blogs for EDUCAUSE, respond to calls for proposals, teach at an EDUCAUSE institute, or simply indicate your general interest in contributing to the profession by completing the EDUCAUSE volunteer form.

Few would argue that time is running out, but it is certainly running short. Our world is changing, and it's important to keep pace. Knowledge of the influential trends and new technologies and how they relate to the top issues in our field can help. Use this report and other EDUCAUSE resources to increase your institution's awareness, ground your visions, and solidify your planning. These resources represent the best thinking in higher education IT because they represent the best thinkers: your peers, your colleagues, and you.

## Acknowledgments

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EDUCAUSE members are amazing. The time members spend to support the association is critical and deeply appreciated. The ECAR Working Group Strategies Committee, the Higher Education Information Security Council (HEISC) Leadership Team, and the HEISC Technologies, Operations, and Practices Working Group in particular provided invaluable feedback on the technologies we should include.

## Trends List and Definitions

We asked about 39 IT trends in this year's research. The 2018 trends apply across a number of different IT domains.

**Adaptive learning**: In adaptive learning models, when a learner interacts with instructional material, the software adapts to the student's learning needs, modifying the content and method accordingly. In this way, adaptive learning provides learners with individualized instruction and, in some cases, improved learning outcomes.

**Agile approaches to change**: Agile software development calls for adaptive planning, continuous improvement, and rapid and flexible response to change. These concepts can also be applied to change management in general. The software design strategies of flexibility and continuous improvement are finding their way into efforts related to strategic planning, desktop management, IT governance, and infrastructure planning.

**Applications and implications of artificial intelligence to higher education**: The incorporation of artificial intelligence capabilities (such as natural language processing and cognitive systems and analytics) into applications, smart machines, and robots carries various implications for instruction, research, student services, admissions, administrative services, and the higher education workforce.

**Bimodal IT**: Traditional IT service focuses on stable operations, while an agile or emergent model emphasizes speed and innovation. The premise of bimodal IT is that both types of service delivery are needed in order for IT operations to create value for the underlying institution.

**Blending of roles and blurring of boundaries between IT and academic/administrative areas**: CIOs and IT organizations are being pushed into new, more integrative roles. Meanwhile, almost all strategic discussions around academic transformation presume the need to integrate a variety of campus organizations to further the teaching and learning mission. Entailed in this blending and blurring of roles are new job titles, new governance models, new skill sets, and new demands for professional development.

**Business process redesign**: Examining and redesigning work processes through business process management can uncover opportunities for greater efficiency, possibly allowing for cost savings or reallocation of resources. Because processes tend to span functional unit boundaries, strategies in this area are most successful when they include multiple units at an institution. Business process encompasses workflow design, systems capabilities, motivation, human resources, policies, rules, funding, and other resources.

**Campus safety**: The safety and security of campus students, faculty, staff, and visitors is a priority for higher education institutions. Institutions regularly evaluate their campus operations to strengthen and improve them. Similarly, the security of campus resources, including IT resources and data, is a concern. Institutions must regularly review and improve IT operations to ensure the security of IT systems and data resources.

**Changing enterprise system architectures, integrations, and workflows**: Colleges and universities run a large set of enterprise-wide computing systems, and options for these systems are expanding and becoming more specialized. In addition, many institutions now choose cloud options, resulting in a mix of systems from different vendors, some on-premises and some in the cloud. These changes require IT to focus on system architecture, integrations, and workflows to ensure adequate interconnection between systems and data, enabling computer systems to effectively share information, automate data-sharing workflows, and efficiently support task workflows for students, faculty, and staff.

**Changing faculty roles**: New instructional models and the innovative use of technology have resulted in faculty serving as coaches, software developers, advisors, and instructional leads to sizable cohorts of adjunct faculty. Team-developed courses and demands for increased access to education that can be delivered in various ways have led to an increased focus on the quality of instruction and the rise of the instructional design profession. The faculty transformation continues as an evolving competitive workplace, and rising higher education costs place new demands on the relevance of higher education.

**Climate change**: Institutions are taking steps to mitigate the magnitude of climate change through green and sustainable technologies, even as they are adapting to the impact of increased severe weather events on areas such as operations, risk management, disaster recovery, and travel.

**Complexity of security threats**: The security threat landscape is increasingly complex, with cloud applications, the Internet of Things, complicated technology architectures, and sophisticated emerging threats, requiring a flexible and layered institutional approach to information security. Finding new tools and technologies to help identify and mitigate these threats is of great importance to IT professionals.

**Compliance environment**: The regulatory environment impacting higher education IT systems and the data contained in those systems can seem labyrinthine. Data elements in many IT systems may be protected by a number of federal, state, and local laws and industry regulations. The complicated regulatory environment can be difficult to understand, making it even harder to secure IT systems in a compliant manner.

**Concerns about institutional sustainability or survival**: Higher education institutions are facing a range of pressures, including competition from for-profit institutions, alternative educational models, decreased revenue from tuition dollars, and, in the case of public institutions, decreased state budget allocations. Combined with internal demands to provide the best educational experiences possible for students, these difficulties may undermine the long-term stability of colleges and universities.

**Contributions of IT to institutional operational excellence**: Information technology is increasingly being used to improve operational efficiency and effectiveness, through activities such as automation, personalization, mobile access, outsourcing, shared services, and process improvement.

**Cross-institutional and international scholarly and research collaborations**: Research collaborations are increasingly the norm, and institutions need to be ready to support a greater quantity of increasingly complex collaborations, working across institutional and international lines. Collaborating with colleagues beyond the institution is getting easier through a variety of options that include enterprise-level collaboration tools as well as free web-based tools. Enterprise tools offer more assurance of privacy and security through the institution's identity management system.

**Cross-institutional partnerships and consortia**: In an effort to be as efficient as possible with enterprise IT systems and services, many institutions look to cross-institutional partnerships and consortia as a way to reduce costs or gain efficiency. In a purchasing consortium, a group of institutions develops a contractual relationship that allows for collective cost savings and the opportunity to work more closely with system and software vendors, including cloud vendors.

**Data-driven decision making**: Data-driven decision making aims to derive meaning from data and determine the best actions to take. This approach to decisions can be incorporated into existing planning and management activities and processes; it can also be programmed into applications to generate real-time, personalized triggers, alerts, and advice for students, faculty, advisors, and other constituents.

**DevOps movement**: DevOps efforts focus on building a collaborative relationship between development and operations staff to improve efficiency and provide better service. Strategies may include streamlining operations by automating and standardizing repetitive tasks and creating self-service applications. An institutional strategy that considers DevOps can take advantage of past work and save time on testing, potentially freeing resources for other activities.

**Digital enterprise strategy**: Some institutions are pursuing an enterprise strategy that emphasizes the use of technology as a competitive differentiator through innovative and often personalized applications to teaching and learning, student services, advising, research, admissions, alumni relations, fundraising, facilities management, etc.

**Digitization of scholarly and research data**: Data today are increasingly produced, used, manipulated, and studied in a digital format. Data management practices must accommodate digital resources throughout their life cycle. Higher education IT must provide researchers with the necessary tools and resources to work with and manage these data, including discipline-specific tools and practices, data visualization, interdisciplinary research support, and more.

**Diversity, equity, and inclusion**: Higher education benefits from a diversity of opinions and insights from myriad sources. Technology can be a key enabler of diversity, equity, and inclusion, allowing all voices to be heard. Another dimension of diversity is accessibility, and both the Department of Justice and the Department of Education have become increasingly active in this area. For the IT organization, diversity/inclusivity issues are relevant to staffing and IT workforce issues.

**Evaluation of technology-based instructional innovations**: The need to know which innovations have the greatest positive impact is more acute than ever. ECAR research on faculty and IT shows that the greatest motivator for faculty to incorporate technology into their teaching is evidence of its benefit to students. Due to the complexity of measuring pedagogical impact, a variety of evaluation methods must be employed to produce the evidence persuasive to key stakeholders.

**Incorporating open standards into enterprise IT architecture**: Getting the typical institution's wide variety of complex enterprise systems to interconnect is difficult. Most enterprises adopt an existing framework to integrate complex business workflows, data architectures, and communications standards between systems. For example, the Open Group Architecture Forum framework for enterprise architecture is a widely adopted set of standards, methods, terminologies, business workflow descriptions, and tools for standardizing systems-planning language and methods and for avoiding dependence on proprietary vendor solutions.

**Incorporating risk-management approaches into IT strategy and service delivery**: "Risk management" is a mechanism for managing uncertainty by identifying and assessing risks that threaten goals and then prioritizing and addressing those risks. As IT strategy and service delivery models evolve, addressing IT risk strategically involves focusing on IT's impact on institutional goals rather than on the simple identification of risks related to physical inventories of assets in isolation.

**Increasing complexity of technology, architecture, and data**: The pace of change in technology continues to increase. As institutions try to keep up, they find that the environments they manage are becoming more and more complex. New technologies need to be incorporated into the environment, older technologies need to be updated, and end users expect it all to work seamlessly. As the IT environment grows, and as cloud services are added to the environment, IT complexity increases.

**Institution-wide data management and integrations**: Next-generation enterprise IT provides agility, scalability, and cost-effectiveness through a combination of applications, architectures, and sourcing strategies. However, it also complicates the challenge of making disparate systems communicate with each other. To provide useful information from many different systems and applications, IT needs an institution-wide strategy for data management that accounts for multiple stakeholder needs, as well as an intentional focus on data integration across many types of systems.

**Internet of Things**: The number of Internet-capable objects is expected to surpass 20 billion by 2020, two-thirds of which will be consumer-level devices, including wearables and other person-based devices that offer the potential for learning about behavior, particularly if they begin to automatically interact with institutional applications. Other opportunities include automating and enhancing infrastructure management. This enormous change will increase bandwidth needs, contribute to privacy and security challenges, introduce new computation needs, and potentially provide enormous opportunities for institutions as they begin to support smart campuses of the future.

**IT as an agent of institutional transformation and innovation**: IT can be the vehicle by which an innovation is realized. At the same time, new breakthroughs in IT can open the door for new innovations and opportunities. Moreover, the power of IT can greatly increase the scope and scale of current initiatives (e.g., the collection and analysis of greater amounts of data provide the basis for new directions for business modeling and technology-enabled student advising).

**Managing mobility (of people, data, institutional resources)**: As mobile devices become ubiquitous, as the Internet of Things expands, and as stakeholders expect seamless connectivity through mobile devices to institutional resources and data, institutions need to consider a number of IT and business processes that cover the management, administration, and support for mobile services, finding a balance between access and control.

**National and global political uncertainty**: Political uncertainty brings implications for IT operations and investments, including areas such as information security threats, support for international and traveling students and scholars, state and federal institutional and grant funding, and potential new or changed policies.

**Reduced reliance on service desk as the primary model for support**: Knowledge management and automation are enabling IT organizations to provide alternatives to supplement the traditional call centers or walk-in service desk support. This helps offset growing demand for IT support, as faculty, staff, and students increasingly want to access institutional resources from their personal devices and environments. Web- or app-based self-help can supplement the hours of the help desk, as are outsourced IT service desks to either supplement or replace institution-staffed service desks.

**Service management (ITSM, ITIL)**: ITSM (IT service management) is the practice of running the IT organization with a focus on delivery of services to constituents in a repeatable, measurable, and proactive way that is aligned with organizational needs. ITIL (information technology infrastructure library) is a framework of service management processes designed to optimize the internal operations of the IT organization. ITIL is a way to operationalize ITSM concepts. Other, complementary processes and frameworks that support ITSM include COBIT (for governance, audit, and compliance), Lean (for continuous improvement), Agile (for development), and DevOps (to integrate development and service delivery).

**Shared services**: Shared services is the provision of a service by one part of an organization or group rather than by multiple parts of the organization, offering decreased costs and greater value for the institution. In contrast to centralization, which typically emphasizes compliance and control, shared services focuses on collaboratively developing business processes and service level agreements that deliver value to the business. Strategies that include leadership engagement, good change-management practices, shared governance, and a long-term financial model will lead to greater success in shared-services efforts.

**Strategic relationships with vendors**: IT is increasingly a service broker and partner rather than a technology provider. This shift allows for a strategic conversation between the institution and vendors, bringing technology investments into closer alignment with institutional mission in the process. In the broker role, IT can ensure that cloud contracts meet institutional needs for data management, security, backup, and more.

**Student success focus/imperatives**: With an increased national focus on student completion, higher education faces a new urgency not only to innovate but also to collaborate across departmental silos to bring about institutional transformation. In an environment of big data, institutions are being called on to change the way they address student success, resulting in more students finishing what they start and developing the skills to contribute to society in and beyond the workplace.

**Ubiquitous digital sources and streams**: Institutional data stores, systems, and applications provide a wealth of information that can be used in analytics initiatives. Increasingly, data from sources such as social media, open educational resources, and the Internet of Things should also be considered potentially important information, presenting institutions with the challenges not only of collecting and harnessing so much data but also of dealing with policy, privacy, and cultural issues related to externally sourced data.

**Use of algorithms to influence institutional and individual choices**: There are risks and benefits of applying either homegrown or proprietary vendor algorithms to personalize and inform instruction, curricula, educational plans, student outcomes, staff hiring and evaluations, etc. Risks include the costs of maintaining homegrown algorithms, lack of transparency in vendor algorithms (and how student success metrics and triggers might be inadvertently affected by changing vendors), and fallout of potential false positives and false negatives.

**User-centered design**: Technology management best practices increasingly emphasize factoring end users' needs and experiences in the design, configuration, deployment, and support of IT services and applications. This has implications for current IT projects, services, processes, and staffing.

**Vendor relationships that bypass IT**: As cloud-based services become increasingly common, individual departments often bypass IT departments and negotiate directly with vendors to select and purchase technology-related services. This practice makes it difficult for IT staff to maintain standards for architecture and integration, and it complicates concerns for information security, compliance, privacy, data management, and data governance.

## Strategic Technologies List and Definitions

We organized the 73 strategic technologies into seven families for the purpose of administering our 2018 survey: analytics, infrastructure and operations, mobile, research and scholarship, security and privacy, social/personal/communication, and teaching and learning. This appendix defines the strategic technologies that we asked about and shows how technologies were grouped into each family.

### Analytics

**Flexible interactive platforms for descriptive and predictive analytics of institutional data**: Flexible interactive analytics platforms allow a wide range of users to perform interactive analysis of institutional data, reflecting a shift away from IT-centric analytics solutions to ones that do not require advanced technical or data-science skills.

**Massively scalable database architectures and software**: Massively scalable database architectures allow for the distributed processing of very large data sets by dividing the work across computer clusters. This technology allows for high performance and highly scalable data management that can handle massive data.

**Mobile apps for institutional BI/analytics**: These mobile apps allow users to access institutional BI and analytics resources and technologies via handheld devices.

**Predictive analytics for institutional performance**: Predictive analytics for institutional performance is the application of analytics for improving institutional services and business practices. It uses modeling to determine what will happen based on historical and transactional data.

**Predictive analytics for student success (institutional level)**: Predictive analytics for student success is the statistical analysis of massive amounts of data to create models that establish risk factors relating to student persistence, retention, and completion. These models enable proactive institutional support of student success.

**Predictive learning analytics (course level)**: Predictive learning analytics is the practice of gathering and analyzing a variety of learner data that results in predictions about the likelihood of future student outcomes in the course. These predictions can be used by students and instructors.

**Talent/workforce analytics**: Talent or workforce analytics uses data from HR or other employee information sources to optimize workforce efforts and promote staff engagement. A mature workforce analytics practice links planning and decisions about staffing to institutional goals.

**Text/content analytics**: Text/content analytics is a set of techniques and processes that analyze unstructured, text-based information to discern themes and patterns that can be used as data for analysis and decision making.

**Uses of the Internet of Things for campus management**: The Internet of Things (IoT) refers to the networking of small, often everyday objects equipped with both computing and sensing capabilities, as well as the capacity to send and receive data via the Internet. For campus management, the IoT is being used in areas such as facilities management, where remote monitoring of conditions can allow more efficiency in HVAC and lighting. In addition, smart devices can alert staff to equipment that needs servicing before a problem arises, and parking monitoring systems can alert students to vacant campus parking spaces.

## Infrastructure and Operations

**Application performance monitoring**: Application performance monitoring tools track the performance of applications in relation to end users' experiences and to internal metrics (for example, for load and capacity) that may be leading indicators of future performance issues. The goal of these tools is to automate tracking and improve the reliability of application performance.

**Blended data center (on premises and cloud based)**: As institutions move services to the cloud, they usually move into a blended environment where they continue to maintain an on-premises data center while also managing a set of services that may run the gamut from software as a service to infrastructure as a service. While cloud-based solutions offer advantages related to agility, performance, and scalability, the blended environment requires a shift in strategy to one that encompasses both environments.

**Cloud monitoring platform to track distributed infrastructure apps, tools, and services (e.g., Datadog)**: The proliferation of cloud applications and services is challenging to support because it can result in a mix of distributed and centralized systems and tools, some under IT's control and some not. Cloud monitoring platforms allow institutions to track the expanding set of cloud resources.

**Data center capacity planning and management tools**: Data center capacity planning allows IT to meet the institution's evolving needs for data center resources such as storage, power load, and cooling capacity. Some vendors provide tools for capacity planning. IT service management frameworks such as ITIL describe subprocesses for capacity management that include business capacity management, service capacity management, and component capacity management.

**Ethernet fabrics**: Ethernet fabrics are a data center network protocol that enables connections between multiple physical and virtual devices as part of an

integrated network system. The goal is to increase flexibility and bandwidth and provide a scalable, low-latency networking approach.

**Institutional support for public-cloud storage (e.g., Box)**: Public-cloud storage options provide easy access, sharing, and backup of files and data. Institutions are moving to such options to provide cloud storage and collaboration services that work with the university's identity management system, integrate with other services, and provide contractual assurances of privacy, security, and uptime.

**Integration platform as a service**: The typical institution's enterprise environment is made up of a complex mix of applications and architectures, some in the cloud and some on-premises, that need to communicate with each other and share data appropriately. Instead of handling data integration in-house, some institutions are turning to integration platform as a service (iPaaS), which is a suite of generally cloud-based services that support and enable integration among disparate systems.

**IPv6**: Internet protocol version 6 (IPv6) is designed to address several problems of IPv4, the most pressing of which is the exhaustion of IPv4 addresses. In addition to simply providing more addresses, IPv6 allows for greater efficiency of IT systems, streamlined systems administration, and security improvements.

**IT accessibility assessment tools**: IT accessibility assessment tools allow institutions to test the designs of their web pages and other online materials to ensure they are usable by individuals with disabilities.

**IT asset management tools (e.g., CMDB)**: IT asset management tools provide an account of the significant components of the IT environment, including dependencies and life cycles. As IT assets expand beyond central IT, both on campus and in the cloud, asset management becomes more complex. IT asset management tools can help institutions better understand, plan for, and make decisions about the resulting technology mix.

**Life-cycle contract management**: Life-cycle contract management refers to a formal process or system for managing contracts from the time of negotiation through compliance to renewal. Life-cycle contract management systems have the potential to create efficiencies and lead to cost savings. They also can increase compliance with regulations and other requirements.

**Next-generation Wi-Fi (e.g., 802.11ah, HaLow**): Next-generation Wi-Fi addresses the increasing need for connectivity related to the Internet of Things (IoT). IoT devices might need more than enterprise Wi-Fi and could require additional hardware, security, and management applications. Next-generation Wi-Fi such as 802.11ah operates at low frequency, offers longer range, requires less power, and allows many more devices to connect to a base station.

**Private-cloud computing**: Private-cloud computing refers to cloud infrastructure operating for a single institution and closed to other use.

Some institutions have used virtualization technologies to run parts of their environments on private-cloud virtualized platforms.

**Service-level reporting tools**: Service-level reporting tools allow institutions to track and report on IT service delivery and management. They facilitate tasks and workflows associated with delivering IT services and track how well the delivery of services conforms to service-level commitments.

**Software-defined networks**: Software-defined networks (SDN) are an approach to designing, building, and operating networks that allow system administrators and network engineers to respond quickly to ever-changing network requirements and to optimize resources. SDNs may do for networks what virtualization has done for servers, allowing administrators to manage the network services in a simpler way and enabling network end users and applications to configure the network according to their needs.

**Tools to support cross-institutional and international collaborations**: Collaborating with colleagues beyond the institution is getting easier through a variety of options that include enterprise-level collaboration tools and free web-based tools. Enterprise tools offer more assurance of privacy and security through the institution's identity management system.

**Uses of APIs**: An API defines how a system interacts with other systems and how data can be shared and manipulated across programs. A good set of APIs is like building blocks that allow developers to more easily use data and technologies from various programs. APIs are used in many ways in higher education—for example, to pull data from the student information system into the learning management system, to integrate cloud-based with on-premises services, as an approach to security, and to access web-based resources.

## Mobile

**Development tools to support multiple key platforms**: Developers must program applications to run on a variety of mobile devices that use different operating systems. Design strategies include responsive web design, which provides an optimal experience across a wide range of devices. Development tools exist that aid cross-platform development.

**High-precision location-sensing technologies**: These technologies enable applications to use precise indoor location, allowing systems to know an individual's location to within a few meters. This precise sensing, combined with the Internet of Things and mobile apps, will make possible more-personalized services and information.

**Mobile app development**: Mobile app development is the organizational capability for the development of mobile applications. Organizations must make

decisions about native apps for specific devices and mobile web development strategies. Issues of accessibility, security, data protection, and responsive web design also must be addressed when considering mobile app development.

**Mobile apps for enterprise applications**: Mobile apps for enterprise applications refers to web-based applications that run on mobile devices and are designed to integrate with all aspects of an organization's businesses and processes. These apps make it possible to access enterprise-wide resources (such as course catalogs, student information systems, and human resource systems) and conduct enterprise transactions from mobile devices.

**Mobile device management**: Mobile device management is the approach an institution takes for the policies, support, and procedures related to the variety of cell phones, tablets, and laptops on campus. Mobile device management involves a balance between the security of institutional data and user convenience and productivity. Some institutions use third-party products and services to manage mobile devices. Considerations include data security issues, support for personally owned equipment, and application management.

## Research and Scholarship

**Cloud-based HPC**: High-performance computing (HPC) requires substantial processing, high-speed connections, and parallel input/output. When HPC is provided by cloud vendors, additional characteristics typical of cloud are inherited: the ability to scale up and down quickly on demand in a pay-as-you-go environment.

**Institutional repositories for research data**: The management and curation of research data—including providing continued access to these data—is an important role for many institutions. In addition, publisher or grant-agency guidelines may require data to be in a repository. Institutional repositories help enable local, ongoing management and access, as well as serve as a place to host and share data where appropriate discipline-specific or national repositories are not available.

**Science DMZ**: Science DMZ provides a network-architecture approach that is optimized for high-performance scientific applications and the transfer of large research data sets over high-speed wide-area networks. It supports big-data movement by improving security, cost-effectiveness, and the nimble handling of large (mostly) scientific data sets. Science DMZ also addresses issues of systematic performance monitoring and file transfer and serves to simplify the use of software-defined networking (SDN) over wide-area network paths.

**Tools to support cross-institutional and international research data-sharing**: A core mission of higher education is research, and researchers are increasingly working with colleagues from other institutions and internationally.

Understanding the issues of sharing research data with these colleagues is paramount for IT to provide the tools and support that enable this sharing. Tools in this space may address issues ranging from metadata to data access, usage rights, and file format interoperability.

**Uses of the Internet of Things for research**: The Internet of Things (IoT) continues to generate vast new amounts of data from a multitude of potentially intersecting IoT devices. Growth in this area will necessarily influence how research is conducted and identify new areas of research.

## Security and Privacy

**Applications of analytics to security (such as user behavioral analytics)**: The application of data-collection and sophisticated analytics within security tools and technologies enables IT organizations to quickly identify and respond to threats to institutional IT systems and data.

**Cloud access security broker**: A cloud access security broker (CASB) is a service that applies institutional security policies, such as authentication and authorization rules, to cloud-based resources. A CASB extends institutional information security policies and practices to the cloud-based services that the institution uses.

**Cloud-based identity services (e.g., Duo, OneLogin, PortalGuard)**: Cloud-based identity services manage identification and authentication processes to IT systems or data. Authentication services ensure that only authorized individuals (or other systems) are permitted to access IT systems and data.

**Cloud-based security services (e.g., Duo, Qualys ThreatPROTECT, cloud-based e-mail security solutions)**: These services are usually used in conjunction with on-premises services and tools to enhance an institution's information security posture.

**Content-aware data loss prevention**: Content-aware data loss prevention (DLP) tools enable the dynamic application of security policy based on the content and the context of data. These tools identify and protect sensitive data elements.

**Database encryption**: Database encryption is the process of encrypting data within a database so that the data are rendered unreadable without the decryption key. Often suggested as a way to protect sensitive data, database encryption can be costly and requires more storage space than a nonencrypted database.

**DDoS prevention products and services**: A distributed denial of service (DDoS) attack uses multiple systems to target a single IT system, swamping that system and preventing authorized users from accessing it. Various products and services can be used to protect institutions from DDoS attacks.

**DNS security**: Domain name systems/servers (DNS) translate textual domain names (such as educause.edu) to IP addresses. DNS security describes a suite of security specifications—such as DNS security extensions (DNSSEC), OpenDNS, or DNS-RPZ—for ensuring the integrity and authenticity of the institutional DNS.

**End-to-end communications encryption**: This type of encryption encrypts digital communication from the sender to receiver as it travels across communications networks.

**Enterprise GRC systems**: This refers to integrated IT applications that typically offer "modules" that help automate institutional governance, risk, and compliance (GRC) processes and reporting, such as managing the policy-development process, tracking legal requirements, monitoring and ensuring that compliance obligations are met, automating risk assessment exercises and tracking mitigation activities, and automating incident or issue tracking.

**E-signature technologies (e.g., DocuSign, Adobe Sign, and SignNow)**: These technologies allow users to electronically sign documents to authenticate the identity of the signer.

**Federated identity technologies**: These technologies and standards are used to share identity information between organizations (or across security domains).

**Next-generation firewalls**: These firewalls incorporate application-level inspection, intrusion prevention, and intelligence from outside the firewall. They differ from stand-alone network-intrusion prevention systems.

**Privacy-enhancing technologies (e.g., limited-disclosure technologies, anonymous credentials)**: Privacy-enhancing technologies and tools protect a user's personally identifiable information during online transactions.

**SIEM (context-aware security)**: Security information and event management (SIEM) tools are used to gather security log data across multiple IT systems and present the data via a single interface for action.

**Threat intelligence technologies**: These services or tools generate and share cyber threat intelligence information with other tools and services (and institutions).

## Social/Personal/Communication

**Blockchain**: Blockchain is a public, distributed ledger of transactions maintained by a peer-to-peer network. Its most notable current use is to support value exchange with Bitcoin, but it has also been considered in the context of credentialing.

**Cryptocurrencies (e.g., Bitcoin)**: Cryptocurrencies are digital currencies that use encryption technologies to control the creation and transfer of the units of currency. Bitcoin is a common example of a cryptocurrency.

**Institutional support for speech recognition**: Speech-recognition systems translate human speech into text or commands. Institutional support for such technologies may focus on straightforward educational applications (e.g., language learning) or improving accessibility for students who are blind or physically disabled or have learning disabilities.

**Integration/uses of voice-user interfaces**: Voice-user interfaces (VUIs) make possible human interaction with computers through a voice/speech platform in order to initiate an automated service or process. A VUI is the interface to any speech application.

**Location-based computing**: Location-based computing uses location data to deliver online content to users based on their physical location, using various technologies including GPS, cell phone infrastructure, and wireless access points.

**Support for use of personal cloud services**: Faculty, staff, and students may use personal cloud services such as Apple's iCloud or Google Drive instead of or in addition to institutionally supported storage services. Institutional support includes guidelines, education, and policies to ensure adequate information security.

## Teaching and Learning

**Active learning classrooms**: Active learning classrooms (ALCs) are student-centered, technology-rich learning environments designed on the principles of active pedagogical approaches. ALCs typically feature movable furniture, large displays, projectors, and other tools that support active learning.

**Adaptive learning**: Adaptive learning is one dimension of personalized learning, which aims to provide efficient, effective, and customized learning paths to engage individual learners. Adaptive learning technology dynamically adjusts to student interactions and performance levels, delivering content in an appropriate sequence that individual learners need in order to make progress.

**Augmented and virtual reality for teaching and learning**: Augmented reality (AR) superimposes graphics, video, text, or other content over a user's field of vision, layering digital content onto the real world. Virtual reality (VR) creates an immersive, 3D environment with which users can interact. These technologies can be used as an experience consumed by the learner or as a programming exercise in which learners create AR and VR experiences.

**Courseware**: Courseware is any digital curricular resource that contains a blend of content, study aids, and instructional expertise. Courseware is typically

housed and delivered by a digital platform or application. Courseware's content is a direct descendent of the textbook, and study aids might include tools such as highlighting, commenting, and ways to interact with learners and instructors. Courseware that contains sophisticated instructional (or tutoring) capability is often called adaptive courseware or adaptive learning technology.

**Digital microcredentials (including badging)**: A digital microcredential is like a mini-degree or certification that conveys information about a competency or skill related to a specific topic area. Digital microcredentials or digital badges can be issued by anyone and typically contain detailed metadata that communicate what the learner has learned or is able to do as a result of earning the credential.

**Games and gamification**: Gamification or game-based learning refers to the use of a pedagogical approach that utilizes gaming designs and principles but that is implemented within a nongame context, such as an instructional setting. Gamified learning environments are meant to support learner engagement and motivation, problem solving, critical thinking, and decision-making skills development.

**Incorporation of mobile devices in teaching and learning**: Mobile devices integrated into courses can be used for course assignments, field work, collaboration, and other activities. Such integration includes ensuring that course content functions well on mobile devices, as well as leveraging the unique capabilities of mobile devices for learning.

**Next-generation LMS/digital learning environment**: Next-generation learning environments replace conventional learning tools with a digital environment based on open standards that can be highly customized to support key learning functions such as analytics, collaboration, and universal design. Such environments are characterized by interoperability, personalization, collaboration, accessibility, and analytics.

**Open educational resources**: Open educational resources (OER) are freely accessible, openly licensed documents and media that may be useful for teaching, learning, assessing, and research. OER are used in various learning settings to include online, face-to-face, and blended, as well as structured learning environments such as college courses and self-paced, student-driven learning.

**Remote proctoring services**: Remote proctoring allows students to take an assessment at a remote location while ensuring the integrity of the exam. Online education, in particular, faces the challenge of conducting trustworthy assessments at a distance. The twin goals of all such systems are to ensure that people taking tests are the people they claim to be and that test-takers do not cheat during the exam.

**Student success planning systems**: Student success planning systems aggregate a broad range of academic, learning, financial, and other data, enabling personnel throughout the institution to collaborate in support of retention and completion.

**Technologies for improving analysis of student data**: These technologies enable immediate access to and rapid analysis of large, complex data sets, making it possible to discern trends in student engagement, in the types of difficulties students are encountering, and in the likelihood of success in attaining credentials across the student body.

**Technologies for offering self-service resources that reduce advisor workloads**: These platforms make tools such as online registration, scheduling, and academic planning available directly to students, enabling those with professional responsibilities for guiding students to reserve in-person appointments for higher-level interactions and counseling on individual issues.

**Technologies for planning and mapping student educational plans**: Educational planning tools allow students and advisors to work together to build customized pathways through the curriculum that are appropriate for each individual's interests and goals. In addition, these technologies offer a reliable way to chart and track progress toward a degree or credential. They also support institutions in the development of schedules that match demand.

**Uses of the Internet of Things for teaching and learning**: The Internet of Things (IoT) refers to the network of small, often everyday objects equipped with both computing and sensing capabilities, as well as the capacity to send and receive data via the Internet. The two dimensions of the curricular use of the IoT are as a way of providing learning data about student activities and as a source of student projects in disciplines such as computer science and engineering. The IoT may also be a domain of student extracurricular activity through makerspaces and related activities.

## Appendix: Methodology

We assessed the 39 IT trends and 73 strategic technologies presented in this report via a single EDUCAUSE survey in the summer of 2017. The survey was distributed to 11,797 EDUCAUSE members as part of the Top 10 IT Issues research, with three reminders sent; 438 individuals (4%) completed the survey. Where multiple representatives from a single institution completed the survey, we selected the response from the representative in the highest-ranking position to determine the top 10 issues. The final top 10 list is based on the responses of 310 US-based respondents.

We reexamine ours lists of trends and technologies annually. The lists in this year's research were derived from the 2017 lists and revised in consultation with EDUCAUSE staff who lead program areas (ELI, ECAR working groups, ECAR research, cybersecurity, and enterprise IT).

Several technologies on the 2017 list were removed. Some were eliminated because they were obscure, were becoming irrelevant as technologies and practices continue to evolve, or were still too nascent in higher education to warrant inclusion (e.g., virtual assistants, autonomic computing). Some technologies were redundant with CDS content or were widespread enough based on the 2017 research to exceed our threshold of existing institutional deployment at no more than 30% of institutions. We refactored other technologies to better describe them and their relevance to evolving practices.

### Trends

We characterized a trend as "influential" if it was already incorporated into IT strategy or exerting a major influence over emerging IT strategy. We used that characterization to classify the trends into four levels of influence, based on the prevalence of influence across institutions:

- **Most influential:** Trends that were already incorporated or exerting a major influence on emerging IT strategy in 61% or more of institutions
- **Taking hold:** Already incorporated or exerting a major influence on emerging IT strategy in 41–60% of institutions
- **Worth understanding:** Already incorporated or exerting a major influence on emerging IT strategy in 21–40% of institutions
- **Limited impact:** Already incorporated or exerting a major influence on emerging IT strategy in 20% or less of institutions

## Technologies

Respondents indicated the attention their institution was planning to devote to each strategic technology in 2018. Respondents selected one of six response options:

- **Don't know:** I don't know what this technology is.
- **No deployment:** None of this technology is in place, and no work will be under way or resources committed for this technology in 2018.
- **Tracking:** Multiple person-days of effort will be assigned but restricted to monitoring and understanding this technology (much more than just reading articles).
- **Planning, piloting, initial deployment:** This technology is not yet available to users; however, meaningful planning for deployment is either in development or in place. Staff are investing significant time (multiple person-weeks of effort) and resources in executing the plan to pilot or deploy this technology within a defined time frame.
- **Expanding deployment:** In 2018, we will move from initial or partial to broader or even institution-wide deployment.
- **Institution-wide deployment:** Full production-quality technical capability is in place, including ongoing maintenance, funding, etc., with deployment potentially supporting institution-wide access.

To minimize "don't know" responses, respondents were presented technologies according to their areas of expertise based on current roles in higher education IT. However, each respondent was given the option to respond to all 112 technologies and trends. As a result, the number of respondents rating individual technologies ranged from 248 to 298 and the number of respondents rating individual trends ranged from 293 to 299.

The final list of strategic technologies—which included 11 items because of a tie for 10th place—is a weighted average of institutions' plans, with the heaviest weight (5) given to expanding deployment, followed by planning/piloting/initial deployment (3), and then tracking (2). Other response options (no deployment, institution-wide deployment, and don't know) were given a weight of zero in our scoring schema.

## Notes

1. Cass Sunstein is among the notable exceptions: Cass R. Sunstein, *Republic.com* (Princeton, NJ: Princeton University Press, 2001).

2. EDUCAUSE tracks these types of established technologies in the Core Data Service because they are widespread enough to enable institution-level benchmarking.

3. This technology was called *iPASS technologies* in 2017. We changed the name in 2018 to more properly reflect the different types of technologies included in this category.