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Higher Education's 2019 Trend Watch and Top 10 Strategic Technologies

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Contents

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EDUCAUSE

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

In Ridley Scott's 1982 epic science fiction film *Blade Runner*, the viewer is presented with a bleak portrayal of a technology-saturated future filled with flying cars, exaggerated industrial landscapes reaching far up into an obliterated atmosphere, and advanced androids (called "replicants") that are nearly indistinguishable from their human counterparts. Noted for its groundbreaking creativity and design, this vision of the future is certainly startling and impressive, perhaps until one realizes that we are now living in the very same year in which the film's events took place—2019—and that we have yet to realize many of the technological advances that decades ago we imagined to be attainable.

Of course, though you may not be reading this report in an automated flying car as you ascend to your 500th-floor office in a towering industrial building, in some ways the future is indeed here now, even as it was envisioned in the fantastical *Blade Runner*. We find ourselves in 2019 wrestling with some of the same ethical implications of our technological advances and navigating some of the same exogenous socioeconomic trends, from state and corporate abuses of power and violations of personal agency, to our ravaged environments and the artificial replacements thereof, and even to the challenging questions around what exactly makes us human and how technology enriches or impoverishes our experiences of being human.

As reflected in this year's data on higher education IT trends and strategic technologies, this future is arriving at our colleges and universities as well, the implications of which will be no less challenging for IT and institutional leaders. Many of the trends and technologies summarized in this report are concerned ultimately with what it means to be a student, for example, and how institutional systems, data, and technologies can enrich the experiences of being a student. Students increasingly find themselves navigating technology-saturated educational environments, whether through the implementation of active learning classrooms or the integration of mobile and other devices with classroom experiences. In helping to scaffold these experiences, higher education IT will continue to demand new resources, models, and innovations, with the drive toward students' thriving and success at the heart of it all.

At the top of the IT Issues list again this year, security remains a perennial concern for institutions and IT professionals. Indeed, along with the exciting advancements in higher education technology inevitably come changes in the threats those technologies represent to the institution. One area in which this may be keenly felt is in the growth of institutional data capabilities and integrations and in the institution's increasing reliance on data for informed,

predictive decision-making and learning facilitation. Institutions—though certainly not the villainous, power-hungry corporations of some dystopian future—must still be vigilant in protecting and accurately using ever-expanding stores of institutional data, and they must continue to develop more effective systems and business models for doing so.

It can be a daunting task for institutions and IT leaders to accurately map the contours of these and other trends and technologies that are only beginning to take shape. Even more challenging, how does one then actively plan and develop strategies for successfully meeting a future that may still seem far off on the industrial horizon? This report is designed to help IT and institutional leaders know where to focus their attention and planning for the trends and technologies that will matter most in the years ahead so that they can see better into the future and respond to it more effectively.

The trends and technologies reviewed in this report were identified through an EDUCAUSE survey conducted in the summer of 2018 and completed by 297 US institutions. This report focuses first on the 2019 Trend Watch, a summary of survey responses to a list of trends and their anticipated level of institutional influence. 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 49 items.

The second section of the report focuses on strategic technologies and the degree to which institutions are paying attention to and implementing these technologies. 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 rather than strategic attention. Strategic technologies, by contrast, are the relatively new technologies institutions will be spending the most time tracking, planning for, and implementing in 2019.

Summary

- The five trends exerting the most influence on higher education's IT strategy are (1) the growing complexity of security threats, (2) student success focus/imperatives, (3) data-driven decision-making, (4) increasing complexity of technology, architecture, and data, and (tied for No. 4) contributions of IT to institutional operational excellence. These are the same five trends that exerted the most influence on higher education's IT strategy in 2018. Each of these trends is influential at 63% or more of colleges and universities.
- Some of the most hyped trends in higher education—adaptive learning, the Internet of Things, alternative credentialing models, and artificial intelligence (AI)—are expected to have only a limited impact on IT strategy in 2019.
- The top 10 strategic technologies are characterized by features that will facilitate student success; improve data collection, security, and use; and support IT business strategies.
- Two technologies—the uses of APIs, and active learning classrooms—remain at the top of the strategic technologies list in 2019. Five other technologies from the 2018 list also appear in the 2019 top 10 list: blended data center, incorporation of mobile devices in teaching and learning, technologies for improving analysis of student data, predictive analytics for student success (institutional level), and IT asset management tools (e.g., CMDB). Additionally, student success planning systems, which rounded out the top 10 in 2018, continues its influence in 2019 as "integrated student success planning and advising systems."
- All institution types are in the planning-expanding phase of deployment for the uses of APIs and active learning classrooms, except associate's and private master's institutions, which are in the tracking-planning phase of these technologies.
- Public and private doctoral institutions are devoting more attention to active learning classrooms than other types of institutions. Early technology adopters are investing more effort in open educational resources and institutional support for accessibility technologies than other institutions. Midsized institutions are focused more on predictive analytics for student success at the institutional level than are smaller institutions
- Next generation Wi-Fi, privacy-enhancing technologies, software-defined networks, uses of the Internet of Things for teaching and learning, and blockchain are among the most-tracked technologies in 2019, a sign of potential future directions.

Collectively, the 2019 top trends and strategic technologies support the three major themes of the Top 10 IT Issues: empowered students, trusted data, and 21st-century business strategies. 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, 2019

This is the fifth year that EDUCAUSE has tracked the influence of major trends on the IT strategy of colleges and universities. Some trends, such as the growing complexity of security threats and artificial intelligence (AI), are technology trends. But we also track environmental trends—such as diversity, equity, and inclusion (DEI) and lifelong learning—that can influence institutional priorities and, in turn, influence technology strategy. We assessed the trends presented in this report via an EDUCAUSE survey in the summer of 2018. The influence of the trends that we studied ranged widely (see figure 1), with some affecting as many as 4 in 5 institutions and others as few as 1 in 14. 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.

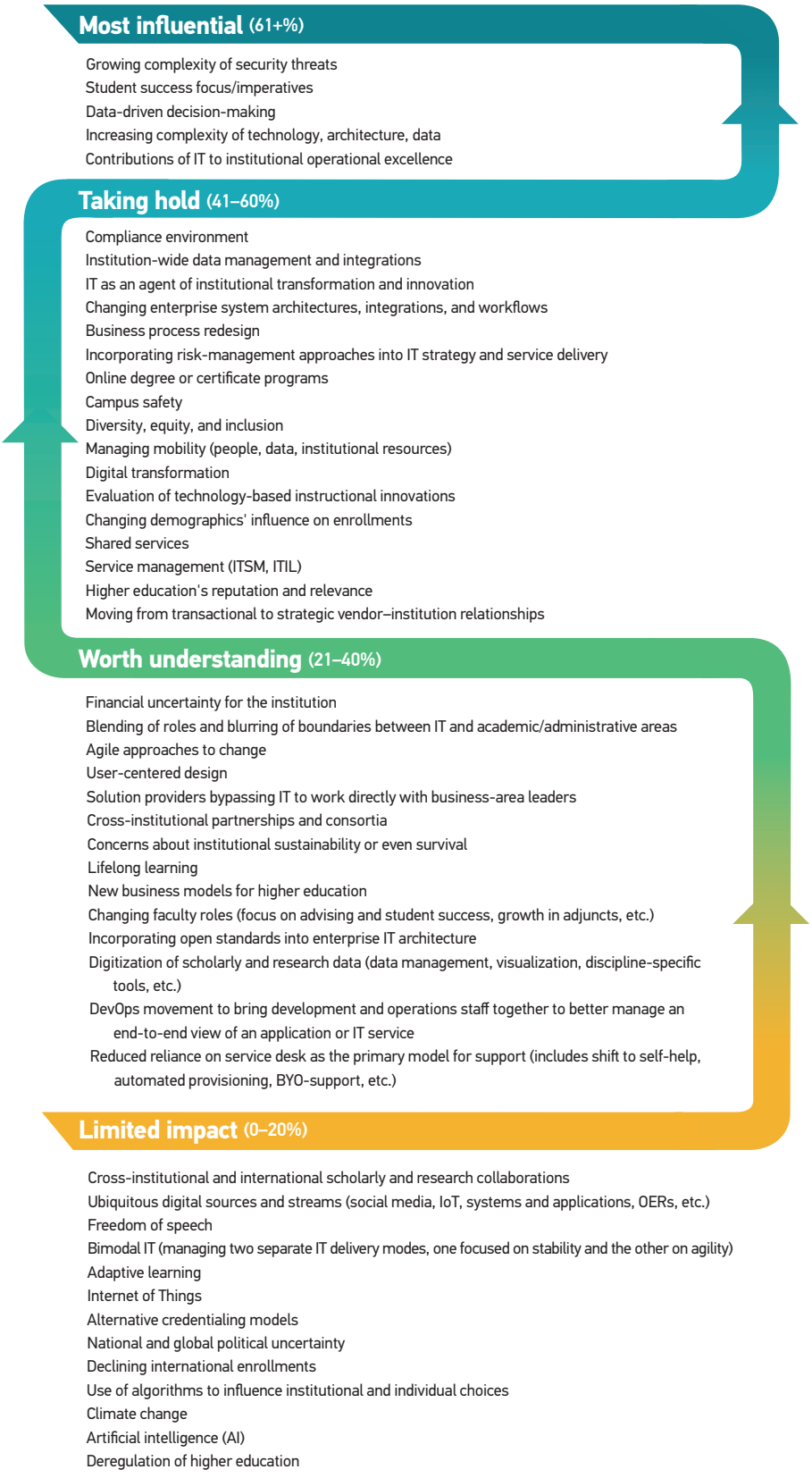

Figure 1. Trends and their influence on IT strategy, 2019

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):

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

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

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

- Compliance environment
- Institution-wide data management and integrations
- IT as an agent of institutional transformation and innovation
- Changing enterprise system architectures, integrations, and workflows
- Business process redesign
- Incorporating risk-management approaches into IT strategy and service delivery
- Online degree or certificate programs
- Campus safety
- Diversity, equity, and inclusion
- Managing mobility (people, data, institutional resources)
- Digital transformation
- Evaluation of technology-based instructional innovations
- Changing demographics' influence on enrollments
- Shared services
- Service management (ITSM, ITIL)
- Higher education's reputation and relevance
- Moving from transactional to strategic vendor–institution relationships

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

The influence of 14 trends is limited to no more than 40% of institutions (listed below from highest to lowest level of influence):

- Financial uncertainty for the institution
- Blending of roles and blurring of boundaries between IT and academic/administrative areas
- Agile approaches to change
- User-centered design
- Solution providers bypassing IT to work directly with business-area leaders
- Cross-institutional partnerships and consortia
- Concerns about institutional sustainability or even survival
- Lifelong learning
- New business models for higher education
- Changing faculty roles (focus on advising and student success, growth in adjuncts, etc.)
- Incorporating open standards into enterprise IT architecture
- Digitization of scholarly and research data (data management, visualization, discipline-specific tools, etc.)
- DevOps movement to bring development and operations staff together to better manage an end-to-end view of an application or IT service
- Reduced reliance on service desk as the primary model for support (includes shift to self-help, automated BYO-support, etc.)

The remaining 13 trends were of limited impact in our research.

- Cross-institutional and international scholarly and research collaborations
- Ubiquitous digital sources and streams (social media, IoT, systems and applications, OERs, etc.)
- Freedom of speech
- Bimodal IT (managing two separate IT delivery modes, one focused on stability and the other on agility)
- Adaptive learning
- Internet of Things

- Alternative credentialing models
- National and global political uncertainty
- Declining international enrollments
- Use of algorithms to influence institutional and individual choices
- Climate change
- Artificial intelligence (AI)
- Deregulation of higher education

The Top 10 Strategic Technologies for 2019

The top 10 strategic technologies for 2019 were identified from a list of 77 technologies. Numbers in parentheses are the 2018 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 (1)
2. Active learning classrooms (2)
3. Blended data center (on premises and cloud based) (7)
4. Incorporation of mobile devices in teaching and learning (3)
5. Open educational resources
6. Institutional support for accessibility technologies*
7. Technologies for improving analysis of student data (5)
8. Application performance monitoring
9. Predictive analytics for student success (institutional level) (8)
10. Integrated student success planning and advising systems (10; tie)
10. IT asset management tools (e.g., CMDB) (10; tie)

**This technology was new in the 2019 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 moveable furniture, large displays, projectors, and other tools that support active learning.
3. **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.

4. **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.
5. **Open educational resources:** Open educational resources (OERs) are freely accessible, openly licensed documents and media that may be useful for teaching, learning, assessing, and research. OERs are used in various learning settings including online, face-to-face, and blended, as well as structured learning environments such as college courses and self-paced, student-driven learning.
6. **Institutional support for accessibility technologies:** A wide range of accessibility technologies are available for students, faculty, and staff with physical, cognitive, or other kinds of disabilities. Institutional support for such technologies may focus on straightforward educational applications (e.g., language learning) or otherwise improving access.
7. **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.
8. **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.
9. **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.
10. **(tie) Integrated student success planning and advising 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.

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.

Institutional Differences

Each technology was assigned an "attention" score that was a weighted combination of intentions to plan for, track, or implement a technology in 2019 (see the Methodology section for more details). The top 10 were the 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 41% of respondents, mainstream 43%, and late adopters 16%.

We found institutional differences for 4 of the 11 technologies in the list (see figure 2). Generally, early technology adopters, public and private doctoral institutions, and mid-sized institutions (8,000-14,999 FTEs) are devoting more attention to strategic technologies than are smaller institutions and those that adopt technology later. Figure 3 offers a summary view of the top 10 strategic technologies by Carnegie class (including technologies that are in the top 10 for specific Carnegie groups but that are not part of the overall top 10). Public and private doctoral institutions are investing more effort into active learning classrooms than associate's, private master's, and non-US institutions. Early technology adopters are devoting significantly more attention to open educational resources and institutional support for accessibility technologies than other institutions. Larger institutions are focusing on predictive analytics for student success at the institutional level significantly more than are smaller institutions, particularly among institutions with 8,000–14,999 student FTEs.

	Devoting more attention than others	Devoting less attention
Active learning classrooms	• Doctorals (public and private)	• Associate's • Private master's • Non-US
Open educational resources	• Early technology adopters	• Mainstream technology adopters • Late technology adopters
Institutional support for accessibility technologies	• Early technology adopters	• Late technology adopters
Predictive analytics for student success (institutional level)	• 8,000–14,999 FTEs	• Fewer than 2,000 FTEs • 2,000–3,999 FTEs

Figure 2. Institutional differences in attention to 4 of the top 10 strategic technologies

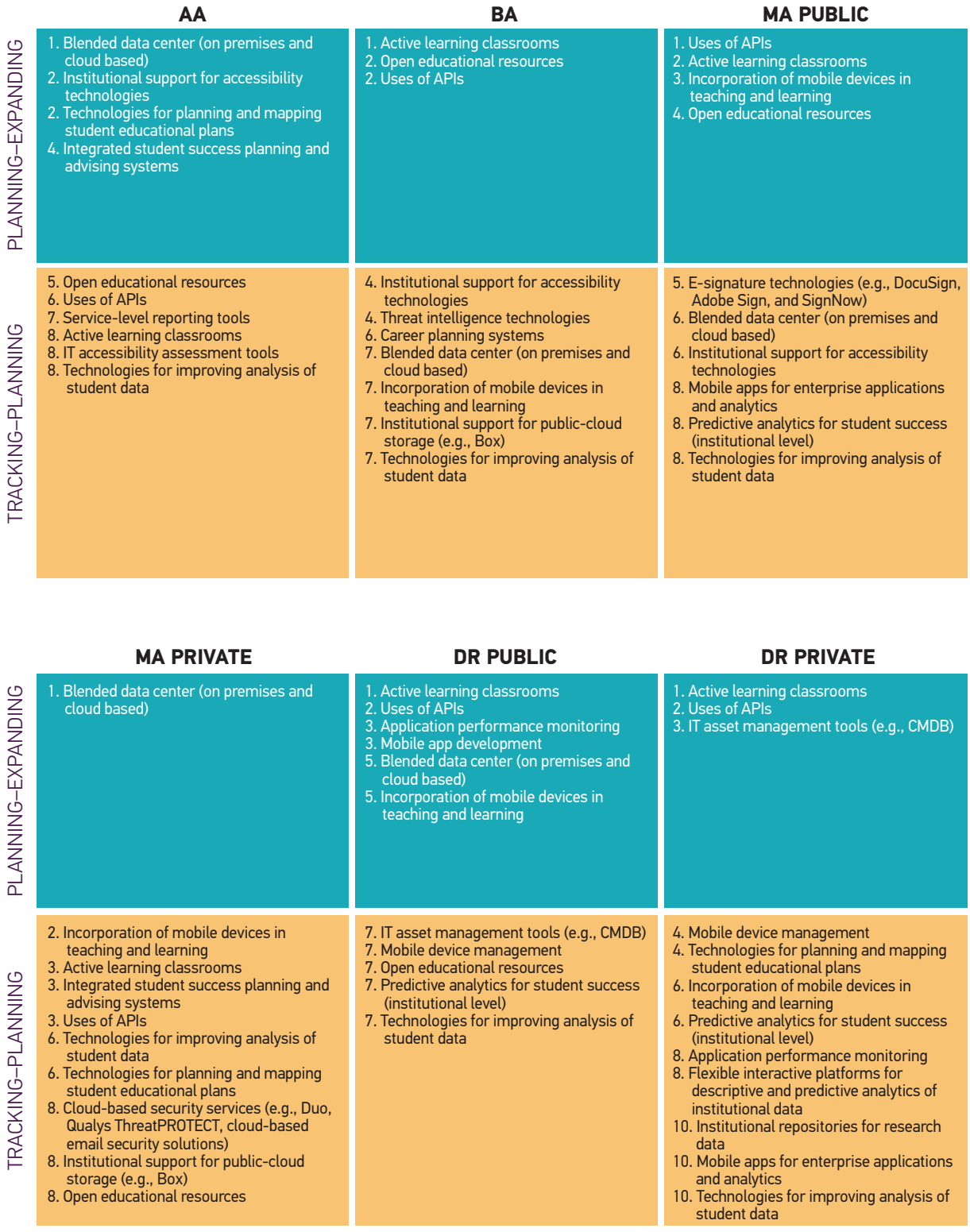

Figure 3. Top 10 strategic technologies for 2019, by Carnegie class

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' 2019 intentions for implementing and planning technologies to estimate deployment of all 77 technologies within roughly two years (2020–21) and within roughly five years (2022–24). 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 2018 top 10 strategic technologies list included 8 of the 11 technologies on this year's list, enabling us to compare our 2018 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 and active learning classrooms would achieve growing adoption by the end of 2020, yet all are still at the experimental level (see figure 4). We also predicted that blended data centers, the incorporation of mobile devices for teaching and learning, technologies for improving the analysis of student data, predictive analytics for student success, and IT asset management tools would be emergent, yet they all remain at the experimental level. Next year's research will afford us the opportunity to finalize our comparison for these seven technologies, at least.

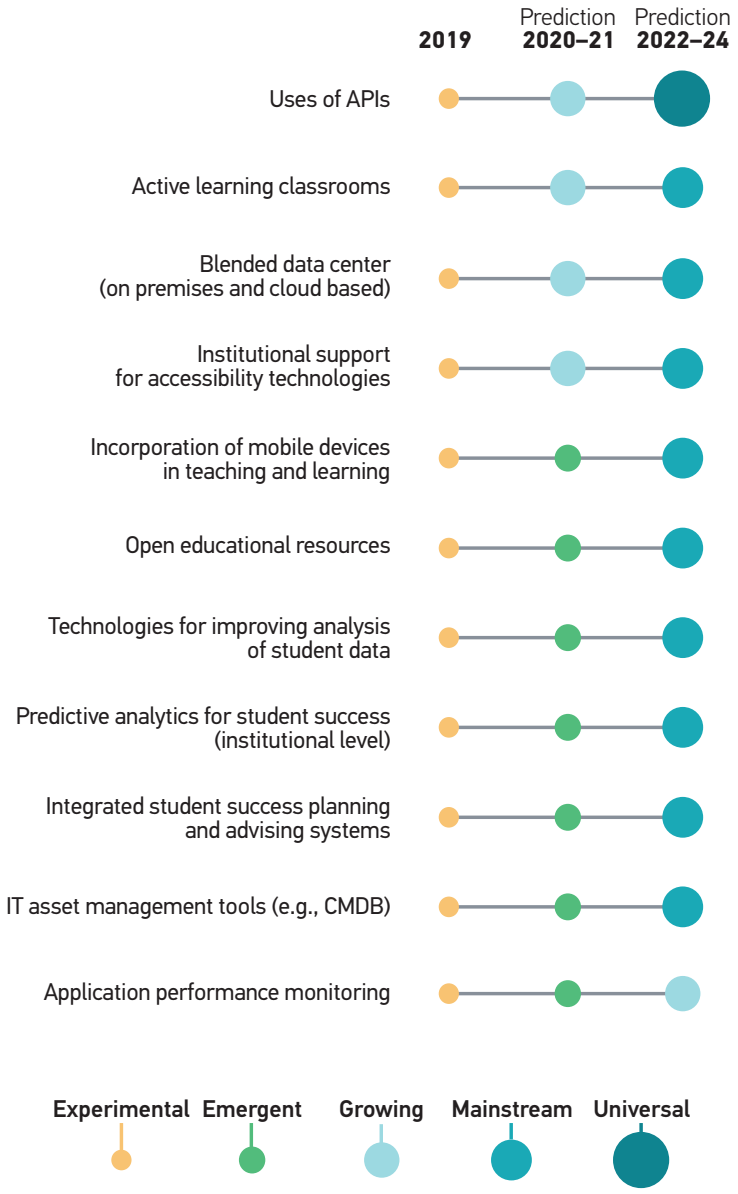

Figure 4. Strategic technologies adoption trends, 2019

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. Ten of the possibly up-and-coming technologies listed below were also on last year's list: next generation Wi-Fi, privacy-enhancing technologies, software-defined networks, applications of analytics to security, games and gamification, next generation digital learning environment,* adaptive learning, digital microcredentials, end-to-end communications encryption,** and content-aware data loss prevention. Next generation digital learning environment, end-to-end communications encryption, adaptive learning, and privacy-enhancing technologies were also among the most widely tracked 2017 technologies. None of the technologies on last year's up-and-coming list made this year's top 10 list.

At least 30% of institutions are tracking these 16 technologies in 2019:

- Next generation Wi-Fi (e.g., 802.11ah, HaLow) (39%)
- Privacy-enhancing technologies (e.g., limited-disclosure technologies, anonymous credentials) (36%)
- Software-defined networks (35%)
- Blockchain (34%)
- Uses of the Internet of Things for teaching and learning (34%)
- Applications of analytics to security (such as user behavioral analytics) (33%)
- Games and gamification (33%)
- Next generation digital learning environment (33%)
- Adaptive learning (32%)
- Identity as a Service (IDaaS) (32%)
- Digital microcredentials (including badging) (31%)
- Location-based computing (31%)
- Content-aware data loss prevention (30%)
- Cryptocurrency malware (30%)
- End-to-end communications encryption (30%)
- Integration/uses of voice-user interfaces (30%)

* In 2018 the technology was listed as "Next-generation LMS/digital learning environment."

** In 2017 the technology was listed as "End-to-end e-mail encryption."

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 three major themes of the Top 10 IT Issues—empowered students, trusted data, 21st-century business strategies—and the individual IT issues, trends, and strategic technologies that most pertain to those themes. Consider conversations and planning sessions for each of the three themes, and explore the extent to which overall major trends and emerging technologies are playing out at your institution. Numbers in parentheses are the rankings for strategic technologies in last year's top 10.

Table 1. Matrix of issues, trends, and technologies

Top 10 IT Issues Theme	IT Issues	Trends	Strategic Technologies
Empowered students In their drive to improve student outcomes, institutions are increasingly focused on individual students, on their life circumstances, and on their entire academic journey. Leaders are relying on analytics and technology to make progress.	2. **Student success:** Serving as a trusted partner with other campus units to drive and achieve student success initiatives 4. **Student-centered institution:** Understanding and advancing technology's role in optimizing the student experience (from applicants to alumni)	• Student success focus/ imperatives • Online degree or certificate programs • Evaluation of technology-based instructional innovations • Changing demographics' influence on enrollments	2. Active learning classrooms (2) 4. Incorporation of mobile devices in teaching and learning (3) 5. Open educational resources 6. Institutional support for accessibility technologies 7. Technologies for improving analysis of student data (5) 9. Predictive analytics for student success (institutional level) (8) 10. Integrated student success planning and advising systems (10)
Trusted data Institutions are securing, integrating, and standardizing data and preparing the institution to use data meaningfully and ethically.	1. **Information security strategy:** Developing a risk-based security strategy that effectively detects, responds to, and prevents security threats and challenges 3. **Privacy:** Safeguarding institutional constituents' privacy rights and maintaining accountability for protecting all types of restricted data 5. **Digital integrations:** Ensuring system interoperability, scalability, and extensibility, as well as data integrity, security, standards, and governance, across multiple applications and platforms 6. **Data-enabled institution:** Taking a service-based approach to data and analytics to reskill, retool, and reshape a culture to be adept at data-enabled decision-making 8. **Data management and governance:** Implementing effective institutional data-governance practices and organizational structures	• Growing complexity of security threats • Data-driven decision-making • Increasing complexity of technology, architecture, data • Compliance environment • Institution-wide data management and integrations • Changing enterprise system architectures, integrations, and workflows • Incorporating risk-management approaches into IT strategy and service delivery • Campus safety	1. Uses of APIs (1) 3. Blended data center (on premises and cloud based) (7) 8. Application performance monitoring

Top 10 IT Issues Theme	IT Issues	Trends	Strategic Technologies
21st-century business strategies This is the leadership journey, in which institutions address today's funding challenges and prepare for tomorrow's more competitive ecosystem. Technology is now embedded into teaching and learning, research, and business operations, and so it must be embedded into the institutional strategy and business model.	7. **Sustainable funding:** Developing funding models that can maintain quality and accommodate both new needs and the growing use of IT services in an era of increasing budget constraints 9. **Integrative CIO:** Repositioning or reinforcing the role of IT leadership as an integral strategic partner of institutional leadership in supporting institutional missions 10. **Higher education affordability:** Aligning IT organizations' priorities and resources with institutional priorities and resources to achieve a sustainable future	• Contributions of IT to institutional operational excellence • IT as an agent of institutional transformation and innovation • Business process redesign • Diversity, equity, and inclusion • Managing mobility (people, data, institutional resources) • Digital transformation • Shared services • Service management (ITSM, ITIL) • Higher education's reputation and relevance • Moving from transactional to strategic vendor–institution relationships	10. IT asset management tools (e.g., CMDB) (10)

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.

Acknowledgments

Many thanks are due to the EDUCAUSE staff who made this report possible. Jamie Reeves led the Top 10 series research project with *some* help from D. Christopher Brooks. Ben Shulman led the statistical analysis, and Kate Roesch developed the graphics that help bring this information to life. Ana Borray, D. Christopher Brooks, Malcolm Brown, Eden Dahlstrom, Veronica Diaz, Susan Grajek, Joanna Grama, Leah Lang, Mark McCormack, Betsy Tippens Reinitz, Valerie Vogel, and Karen Wetzel advised on the choices, definitions, and categorization of technologies. Gregory Dobbin provided his usual expert editorial review. Lisa Gesner led the marketing strategy for our entire Top 10 series research.

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 49 IT trends in this year's research. The 2019 trends apply across a number of different IT domains.

Adaptive learning: Adaptive learning is typically made possible in digital or technologically mediated environments, although it can also be applied to face-to-face learning environments. 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. A unique feature of adaptive learning is that in some cases it can analyze the learning history of the individual using the software and provide interactive adjustments based on the individual's understanding and ability to learn.

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. With the rapid pace of technological advances, the decreasing ability of IT shops to control users' technology ecosystems, and leadership demands for increased accountability, IT strategies that take an agile approach to change management are critical. 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. In addition, institutions working to develop a culture of innovation may find that agile approaches increase cost-effectiveness.

Alternative credentialing models: Certificates, credentials, and job-related curricula are increasingly relevant alternatives to traditional degrees.

Artificial intelligence (AI): Incorporating AI capabilities (such as natural language processing, cognitive systems, and analytics) into applications, smart machines, and robots has implications for instruction, research, student services, admissions, administrative services, and the higher education workforce.

Bimodal IT (managing two separate IT delivery modes, one focused on stability and the other on agility): This trend attempts to resolve two separate and sometimes competing IT service delivery modes. The first mode can be thought of as traditional IT service delivery, with a focus on stable operation. The second can be thought of as agile or emergent, with a focus on providing IT services in a way that emphasizes speed and innovation. The premise of bimodal IT is that both types of service delivery are needed for IT operations to create value.

Blending of roles and blurring of boundaries between IT and academic/administrative areas: This trend is in evidence across all dimensions that involve the application of IT. Discussions around the issue of digital transformation have suggested new, more integrative roles and skills for the CIO and the IT organization, such as the ability to collaborate and share responsibility with academic and administrative departments and the need to integrate numerous solutions to support institutional and individual decision-making and work. On the teaching and learning side, almost all strategic discussions around academic transformation take as a starting point 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. For example, business process redesign can decrease the need for customization of enterprise systems and increase alignment between business processes and institutional mission. A move to the cloud can be a catalyst for examining business processes in this way. 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 is more than simply workflow; it encompasses workflow design, systems capabilities, motivation, human resources, policies, rules, funding, and other resources. All should be considered in a business process redesign strategy.

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

Changing demographics' influence on enrollments: Populations of developed countries are aging, and the traditional 18- to 25-year-old student population is shrinking in absolute terms and as a proportion of enrollments.

Changing enterprise system architectures, integrations, and workflows: The many facets of higher education require colleges and universities to run a large set of enterprise-wide computing systems. Options for these computing systems are expanding and becoming more specialized. In addition, the sourcing of those systems is evolving. Whereas IT once ran all enterprise systems on premises, many now choose cloud options, with the result being 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 many different computer systems to effectively share information, automate data-sharing workflows, and efficiently support task workflows for students, faculty, and staff.

Changing faculty roles (focus on advising and student success, growth in adjuncts, etc.): Prompted by sociological, technological, and economic forces, the role of the faculty member in higher education has significantly transformed over the past 20 years. 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. In his paper on the unbundling of the faculty role, Vernon Smith points to the disaggregation of faculty work to include teaching, course design, assessment, and advising. 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: Responding to concerns about climate change, colleges and universities are taking steps to mitigate the magnitude of their environmental impact through green and sustainable technologies. Institutions are also adapting to the impact of increased severe weather events on areas including operations, risk management, disaster recovery, and travel.

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 different 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 even survival: Higher education institutions are besieged by a host of external challenges that include 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 pressures may undermine the long-term stability of many colleges and universities.

Contributions of IT to institutional operational excellence: IT can be used to improve operational efficiency and effectiveness through areas including automation, personalization, mobile access, outsourcing, shared services, and process improvement.

Cross-institutional and international scholarly and research collaborations: Research collaborations are increasingly common, and institutions need to be ready to support not only a greater quantity of collaborations but also more complex collaborations. These include working with multiple institutions and working across international lines. 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.

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 possible way to reduce costs or gain efficiency. In a purchasing consortium, for example, 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: As a corollary to analytics, colleges and universities are increasingly deriving meaning from the data and determining the best actions to take. Data-driven decision-making can be incorporated into existing planning and management activities and processes, or it can be programmed into applications to generate real-time, personalized triggers, alerts, and advice for students, faculty, advisors, and other constituents.

Declining international enrollments: The political climate has made US higher education less appealing to international students. In addition, other countries are investing aggressively in expanding their own higher education sectors.

Deregulation of higher education: The US Department of Education is revisiting several key Obama-era programs, which could lead to less regulatory oversight.

DevOps movement to bring development and operations staff together to better manage an end-to-end view of an application or IT service: DevOps efforts usually emphasize people over tools, focusing 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. Lack of a current standard definition can create confusion, and the DevOps implementation that works for one institution may not work for another. A strategy that adopts a simplified definition can be a good starting point for developing a common understanding for developers and operations staff.

Digital transformation: Digital transformation is a cultural, technological, and workforce shift. In its cultural dimension, it requires a new approach to how campus leaders interact with each other as well as an emphasis on change management and a movement toward institutional agility and flexibility to meet quickly changing needs. For IT, this means adopting a role of strategic and transforming partner in alignment with institutional mission. In terms of technology, IT leaders and their organizations must adopt innovative practices and create new digital architectures that give it unprecedented agility and flexibility to enable the institution to rapidly and efficiently achieve its strategic aims. Finally, digital transformation has broad implications for the institutional workforce, requiring dramatic shifts in workplace skills at all levels and for professional development that enables the workforce to keep pace with the rapid tempo of change.

Digitization of scholarly and research data (data management, visualization, discipline-specific tools, etc.): Data today are typically produced in a digital format and are increasingly being used, manipulated, and studied in scholarship and research in digital ways. Data management practices must be updated to work with digital data throughout its life cycle. Higher education IT must also be aware of and able to provide researchers with the tools and resources necessary to work with and manage these data, including discipline-specific tools and practices, data visualization, research support for both traditional and more nascent areas of study (such as digital humanities), interdisciplinary research support, and more.

Diversity, equity, and inclusion: Diversity and inclusivity are the lifeblood of higher education. Science and scholarship can only proceed on the basis of encouraging a diversity of opinions and insights proffered by myriad sources. Technology is a key enabler of this dimension, making it possible to draw on diverse information resources and allowing all voices to be heard. In the domain of teaching and learning, the issue of accessibility—one dimension of diversity/inclusivity—jumped from 7th to 4th in the ELI key issues survey. For the IT organization, diversity/inclusivity issues are highly relevant to the issue of sustainable staffing as well as to IT workforce issues.

Evaluation of technology-based instructional innovations: Evaluating the impact of technology-based innovations in teaching and learning has long been a key issue. In light of increasing demands for technology and support, often dogged by dwindling resources, 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 utilized to produce the evidence persuasive to key stakeholders.

Financial uncertainty for the institution: A combination of factors, including declining enrollments and reduced government funding, is endangering some institutions' financial health and outlook.

Freedom of speech: When free speech, inclusion, and civility are at odds, individual safety and institutional reputations can be at risk. This issue is playing out on campuses through controversies around trigger warnings, invited speakers, and expression of controversial viewpoints. Social media plays a role.

Growing 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 information security approach. Finding new tools and technologies to help identify and mitigate these threats is of great importance to IT professionals.

Higher education's reputation and relevance: The value of a college degree and an educated citizenship are under increasing scrutiny.

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 or standard for how complex business workflows, data architectures, and communications standards between systems will work to produce a truly integrated computing environment. For example, The Open Group Architecture Forum framework for enterprise architecture is a widely adopted set of standards, methods, terminology, 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: The term "risk management" refers to a detailed, thoughtful process whereby an institution identifies and assesses the risks that could keep it from meeting its goals and then creates a plan for prioritizing and addressing those risks. It is a mechanism for managing uncertainty. As IT strategy and service delivery models evolve beyond traditional offerings, addressing IT risk strategically involves focusing on information technology's impact on the achievement of institutional goals rather than on the simple identification of risks related to physical inventories of assets in isolation.

Increasing complexity of technology, architecture, data: As the IT environment grows, and as cloud services are added to the environment, IT complexity increases. New technologies need to be incorporated into the environment, older technologies need to be updated, and end users expect it all to work seamlessly.

Institution-wide data management and integrations: New digital architectures provide agility, scalability, and cost-effectiveness through a growing combination of applications and sourcing strategies. However, it also complicates the challenge

of making all those disparate systems communicate with each other. To provide useful information from so many different systems and applications, IT needs an institution-wide strategy for data management that takes multiple stakeholder needs into account and focuses on data integration across many different types of systems.

Internet of Things: The number of computers and servers connected to the internet is being dwarfed by the number of other physical objects with embedded internet-capable technology. Gartner estimates that the IoT will encompass more than 20 billion devices by 2020, a fourfold increase from 2015. Two-thirds of those devices will be consumer-level devices. 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. Perhaps the most obvious opportunities initially will be in automating and enhancing infrastructure management. But wearables and other person-based devices offer the potential for learning more about people's behavior, particularly if such devices begin to interact with institutional applications.

IT as an agent of institutional transformation and innovation: IT has always had a dual role with respect to transformation and innovation: IT can be the vehicle by which an innovation is realized, and new breakthroughs in IT can open the door for a new set of innovations and opportunities that were scarcely imaginable before. There is no indication that IT will relinquish this dual role; indeed, if anything, the pace of such change only seems to be accelerating. Finally, the power of IT can greatly increase the scope and scale of current initiatives—for example, the collection and analysis of greater amounts of data provide the basis for new directions for business modeling and technology-enabled student advising.

Lifelong learning: The potential student population can extend to all adults, as the need for ongoing learning and retooling increases.

Managing mobility (people, data, institutional resources): As mobile devices become more 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 is important.

Moving from transactional to strategic vendor–institution relationships: Digital transformation is characterized by a shift in IT's role from being a technology provider to a service broker and partner. This shift allows for a different level of conversation between institution and vendor, as IT can broker a strategic conversation between the two, 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.

National and global political uncertainty: Political uncertainty and unrest can lead to uncertainty about non-US enrollments, employment of non-US citizens, institutional and grants-based funding, compliance requirements, performance-based funding, free speech, and more. This may have implications for IT operations, funding, and priorities.

New business models for higher education: Institutions are experimenting with new business models, some of which entail collaborations with nonprofit and for-profit institutions, involve digital resources, and have concrete ROI expectations.

Online degree or certificate programs: Many institutions are considering or adding new online programs to grant degrees or certifications.

Reduced reliance on service desk as the primary model for support (includes shift to self-help, automated provisioning, BYO-support, etc.): Knowledge management and automation are enabling IT organizations to provide alternatives to supplement the traditional model of service desk support, a walk-in or call center. This helps offload growing demand for IT support, as faculty, staff, and students increasingly want to access institutional resources from their personal devices and environments. Support staff are challenged to keep up with the complexity of supporting so much variety. Web- or app-based self-help is also an efficient way to supplement the hours of the help desk to provide 24/7 support, as are outsourced IT service desks to either supplement or, in some cases, replace institution-staffed service desks.

Service management (ITSM, ITIL): As colleges and universities increasingly expect their IT departments to deliver services and, more importantly, value, ITSM and ITIL are receiving considerable attention. 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—such as change, incident, and configuration management—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 services by one part of an organization or group that were previously provided by more than one part of the organization. Shared services offers an economy of scale that may lead to decreased costs and greater value for the institution. However, attaining

that economy of scale can require a large and challenging scope expansion. A shared-services solution differs from centralization in that the former focuses on collaboratively developing business processes and service level agreements that deliver value to the business. Centralization typically emphasizes compliance and control more than service value. 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.

Solution providers bypassing IT to work directly with business-area leaders: As cloud-based services become increasingly common, individual departments often negotiate directly with vendors and bypass IT departments 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. IT departments are responding in part by developing expertise in relationship management skills, allowing them to communicate better with both campus stakeholders and the vendor community.

Student success focus/imperatives: With an increased 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 (social media, IoT, systems and applications, OERs, etc.): 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 can also be considered as sources of important information, presenting institutions with the challenges of how to collect and harness so much data, as well as how to deal with policy, privacy, and cultural issues related to the use of externally sourced data.

Use of algorithms to influence institutional and individual choices: Applying homegrown or proprietary vendor algorithms to personalize and inform instruction, curricula, educational plans, student outcomes, staff hiring and evaluations, and other areas carries risks as well as benefits.

User-centered design: Colleges and universities need to give extensive consideration to end-user needs and experiences in the design, configuration, deployment, and support of IT services and applications.

Strategic Technologies List and Definitions

We organized the 77 strategic technologies into seven families for the purpose of administering our 2019 survey: analytics, infrastructure and operations, mobile, research and scholarship, security and privacy, social/personal/communication, and teaching and learning. This list defines the strategic technologies that we asked about and shows how technologies were grouped into each family.

Analytics

Career planning systems: These technologies allow students to engage in career planning, including previewing job-market data, salary data, and the financial impact of choosing a degree that prepares them for that career.

Course demand forecasting: These technologies use student program data to forecast course demand. They can be used for course scheduling and course forecasting. These solutions allow institutions to ensure they are offering the curriculum needed in the right sequence to support student success and completion.

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: A typical institutional 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 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 that operates for a single institution and is 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 (SDNs) 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 and analytics: 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, e.g., 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 this 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 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 email 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.

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.

DevOps/DevSecOps: DevOps is the culture and practice that unifies software development and software operation into shorter development cycles, enabling organizations to deliver services and applications at a faster pace than organizations using traditional software development practices and processes. DevSecOps is the philosophy and practice of incorporating security into each step of the software development process to deliver more secure services and products; it requires close collaboration between software engineers and security teams.

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 approach encrypts digital communications 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).

Identity as a Service (IDaaS): Identity as a Service (IDaaS) is a cloud-based service that is created, hosted, and managed by a third-party provider. IDaaS might include cloud-based authentication infrastructure or access controls, single sign-on (SSO), adaptive multifactor authentication (MFA), and other identity and access management (IAM) functions. In addition to providing improved cybersecurity, IDaaS offers more efficiency because identity provisioning, password resets, software upgrades, and other administrative work can be handled by the service provider.

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 cyberthreat 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.

Cryptocurrency malware: Cryptocurrencies (such as Bitcoin) are digital currencies that use encryption technologies to control the creation and transfer of the units of currency. Cryptocurrency transactions are verified through a process known as "mining," which requires significant computing resources. In some instances, an end user's computer or device can be used for mining without the user's permission. This unauthorized use of resources for cryptocurrency mining can be an information security concern.

Institutional support for accessibility technologies: A wide range of accessibility technologies are available for students, faculty, and staff with physical, cognitive, or other kinds of disabilities. Institutional support for such technologies may focus on straightforward educational applications (e.g., language learning) or otherwise improving access.

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 moveable 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.

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 communicates 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.

Integrated student success planning and advising 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.

Next generation 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 (OERs) are freely accessible, openly licensed documents and media that may be useful for teaching, learning, assessing, and research. OERs are used in various learning settings including online, face-to-face, and blended, as well as structured learning environments such as college courses and self-paced, student-driven learning.

Open standards for educational and learning technologies: Open standards are the linchpin for next generation digital learning environments. These standards enable applications to integrate quickly and inexpensively, and they also make possible the aggregation of learning data across a variety of tools and platforms. Open standards should be a component of digital architecture planning and be required in procurement practices.

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.

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 act 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.

XR (including virtual/augmented/mixed) 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.

Appendix: Methodology

We assessed the 49 IT trends and 77 strategic technologies presented in this report via a single EDUCAUSE survey in the summer of 2018. The survey was distributed to 11,397 EDUCAUSE members as part of the Top 10 IT Issues research, with three reminders sent; 405 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 297 US-based respondents.

We reexamine ours lists of trends and technologies annually. The lists in this year's research were derived from the 2018 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 2018 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 2018 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 2019. 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 2019.
- **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 2019, 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 126 technologies and trends. As a result, the number of respondents rating individual technologies ranged from 246 to 278, and the number of respondents rating individual trends ranged from 272 to 281.

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.