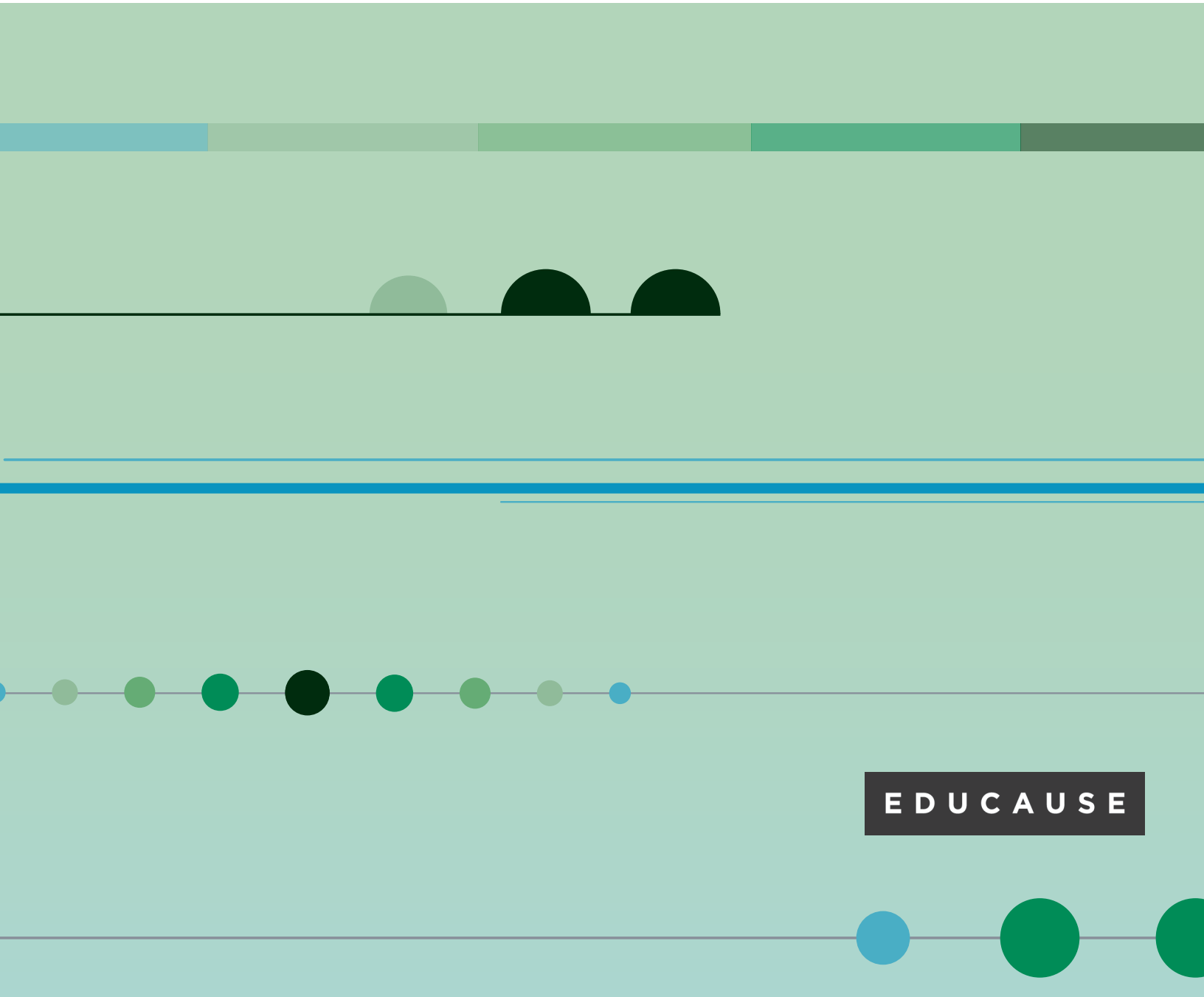
EDUCAUSE CENTER FOR ANALYSIS AND RESEARCH

Higher Education's Top 10 Strategic Technologies for 2016



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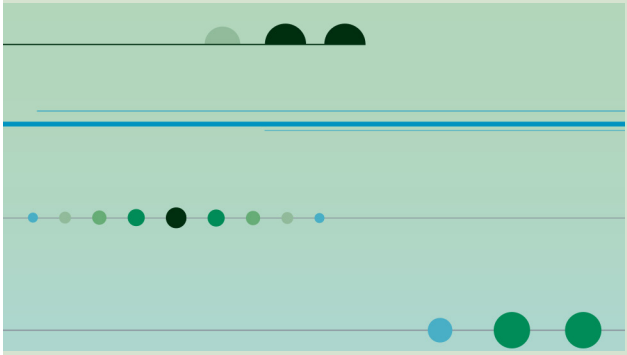

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EDUCAUSE

EDUCAUSE is a nonprofit association and the foremost community of IT leaders and professionals committed to advancing higher education. EDUCAUSE programs and services are focused on analysis, advocacy, community building, professional development, and knowledge creation because IT plays a transformative role in higher education. EDUCAUSE supports those who lead, manage, and use information technology through a comprehensive range of resources and activities. For more information, visit educause.edu.

Introduction and Overview

The theme for 2016's top 10 IT issues is Divest, Reinvest, and Differentiate. Colleges and universities are eager to use information technology to differentiate themselves from other institutions in the way they deliver teaching and learning and facilitate student success. To make room for new investments in educational technologies and analytics, IT organizations are working to simplify existing infrastructure and baseline services, integrate data and applications, and manage a pervasive and escalating set of information security threats. The top 10 IT issues are strategic and of interest to presidents, governing boards, provosts, CBOs, faculty, and students, as well as IT professionals. Technologies underlie almost all the 2016 issues. The 2016 top 10 strategic technologies complement the top 10 IT issues by identifying the emergent technologies institutions are implementing as they divest, reinvest, and differentiate with IT.

This is a report of the technology investments institutions are making in 2016, not simply the technologies IT professionals are reading or talking about. It provides a snapshot of the new technological investments colleges and universities are actually planning and implementing in 2016, as well as technologies they are tracking or simply not addressing for the time being. Institutions can use it as a guide to consider which technologies they might focus on, where they might be lagging, and where they might be leading.

Our focus is on strategic technologies. We define a technology as "strategic" based on the time, active attention, and priority devoted to it at a given time. Mature, more commonly deployed technologies (such as financial information systems or networks) may be among the most mission-critical technologies (and thus strategic in a different sense), but they are generally more likely to receive operational than strategic attention. EDUCAUSE tracks those established technologies in the Core Data Service[1] because they are widespread enough to enable institution-level benchmarking. Strategic technologies, by contrast, are relatively new technologies institutions will be spending the most time implementing, planning for, and tracking in 2016. IT leaders and professionals are particularly interested in whether and when to invest in these still-maturing technologies. None of the 83 technologies covered in this report is currently in place in more than 30% of institutions. That may not be the case for long: 45–64% of institutions intend to plan for or implement the top 10 strategic technologies in 2016.

The top 10 strategic technologies were selected from the analysis of a vetted set[2] of 83 technologies presented to EDUCAUSE members in a survey in summer 2015, as described in this report's Methodology section. This report does not aim to justify or assess these technologies; a number of excellent existing resources already do that. The value of the EDUCAUSE list is that it is based on data about members' actual plans and thus sheds light not on what people are talking about but on what institutions are doing.

The top 10 strategic technologies in higher education complement the popular EDUCAUSE Top 10 IT Issues.[3] Together, the two resources can provide more complete and nuanced guidance on institutional IT priorities. A third report, *Trend Watch 2016*, summarizes the influence on institutional IT strategy of trends such as moving to the cloud, data-driven decision making, and personalized learning.[4] It provides yet more context and insight to guide IT strategy.

Key Findings

- IT departments are working on multiple fronts to divest existing technologies and practices, reinvest in information security and mobile, and use analytics and educational technologies to differentiate their institution. This year's top 10 technologies list is quite diverse, spanning technologies in mobile, analytics, security, application management and delivery, service desk management, business performance, and teaching and learning.
- Although mobile technologies appear frequently on the list, unlike last year they do not predominate. Last year's list included seven mobile-related technologies, and this year's contains four.
- Analytics is permeating many higher education functions, appearing on the list in relation to learning, business performance, information security, and application performance.
- Institutions are balancing differentiation with divesting and reinvesting. Institutions are paying attention to technologies that can refactor the management and delivery of IT services, as well as to selected mission-based or business-related technologies. The domains we predict will make the most progress over the next five years through technology adoption are analytics, cloud sourcing, communications/networking, and—only within doctoral universities—research and scholarship.
- Three technologies that were among the 2015 top 10 were moved to EDUCAUSE Core Data Service benchmarking because they are becoming more widespread (that is, they are already deployed institution-wide in more than 30% of institutions): business intelligence (BI)/reporting dashboards (the No. 1 strategic technology in 2015), enterprise identity and access management solutions (No. 4), and unified communications and collaboration (No. 7).
- For the first time in the three years we have been conducting this research, we predict that one of the top 10 technologies—service desk tool and management strategy—will be "universal" (deployed in 81–100% of institutions) within the next five years. Seven others will achieve "mainstream" adoption (deployed in 61–80% of institutions): incorporation of mobile devices in teaching and learning, SaaS (software as a service), business performance analytics, mobile app development, accessing online components of blended/hybrid courses from mobile devices, mobile apps for enterprise applications, and learning analytics.

- Further out, institutions are devoting the most attention to tracking these technologies: next-generation learning management systems (LMSs), adaptive learning, mobile data protection, use of big data in learning analytics, uses of the Internet of Things (IoT), games and gamification, cloud-based security services, software-defined networks, open educational resources (OERs), and use of big data in institutional analytics. These technologies may be among the top 10 in future years.

The Top 10 Strategic Technologies for 2016

(Numbers in parentheses are the 2015 rankings.)

1. Incorporation of mobile devices in teaching and learning (7)
2. SaaS (software as a service)*
3. Administrative or business performance analytics (4)
4. Mobile app development (responsive design, hybrid, etc.) (2)
5. Accessing online components of blended/hybrid courses from mobile devices†
6. Mobile apps for enterprise applications (3)
7. Service desk tool and management strategy‡
8. Learning analytics§
9. Data collection and sophisticated analytics methodologies for information security (18)
10. Application performance monitoring (new in the 2016 survey)

* This technology appeared as *Cloud-based administrative/enterprise applications* and was 30th in 2015.

† This technology appeared as *Courses on mobile devices: Blended/hybrid (part online/part classroom) courses* and was 20th in 2015.

‡ This technology appeared as *Service desk workforce management tools* and was 45th in 2015.

§ This technology was significantly refactored for 2016. In 2015, we tracked *Learning analytics: degree advising* (11), *Learning analytics: course level* (15), *Predictive analytics for other* [not administrative/business performance] *applications* (50), and *Use of big data in analytics* (37). In 2016, we changed to *Learning analytics*, *Predictive analytics for learning* (27), and *Use of big data in learning* (56).

Descriptions

1. **Incorporation of mobile devices in teaching and learning** means adopting these devices as tools to enhance the learning experience for students and the teaching experience for faculty. This could mean an extension of the classroom to the anytime, anywhere learning environment. It could also mean leveraging common mobile device features and applications to increase productivity, capture and archive course material, share information, and support the shift from students as consumers to students as creators. The unrealized value lies in using mobile technology to facilitate creativity, engagement, and interaction—all demonstrated to have a positive impact on student outcomes.
2. **SaaS (software as a service)** is a software delivery method that provides access to externally hosted applications via a network. A major benefit is that local IT staff no longer need to maintain and support application hardware and software. SaaS is most commonly used in relation to cloud computing.
3. **Administrative or business performance analytics** is the use of analytics techniques and technologies to help target organizational resources to support organizational goals. Administrative or business performance analytics focuses on the collection, analysis, and reporting of business data (such as financials, resource allocation, and productivity) to improve organizational success.
4. **Mobile app development** (responsive design, hybrid, etc.) 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.
5. **Accessing online components of blended/hybrid courses from mobile devices** is one form of incorporation of mobile devices in teaching and learning. It is not the provision of fully online courses on mobile devices, but instead digitally enhanced learning environments that ensure the online parts of blended or hybrid courses work on mobile devices.
6. **Mobile apps for enterprise applications** refers to web-based applications that run on mobile devices such as smartphones 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 to conduct enterprise transactions from mobile devices.

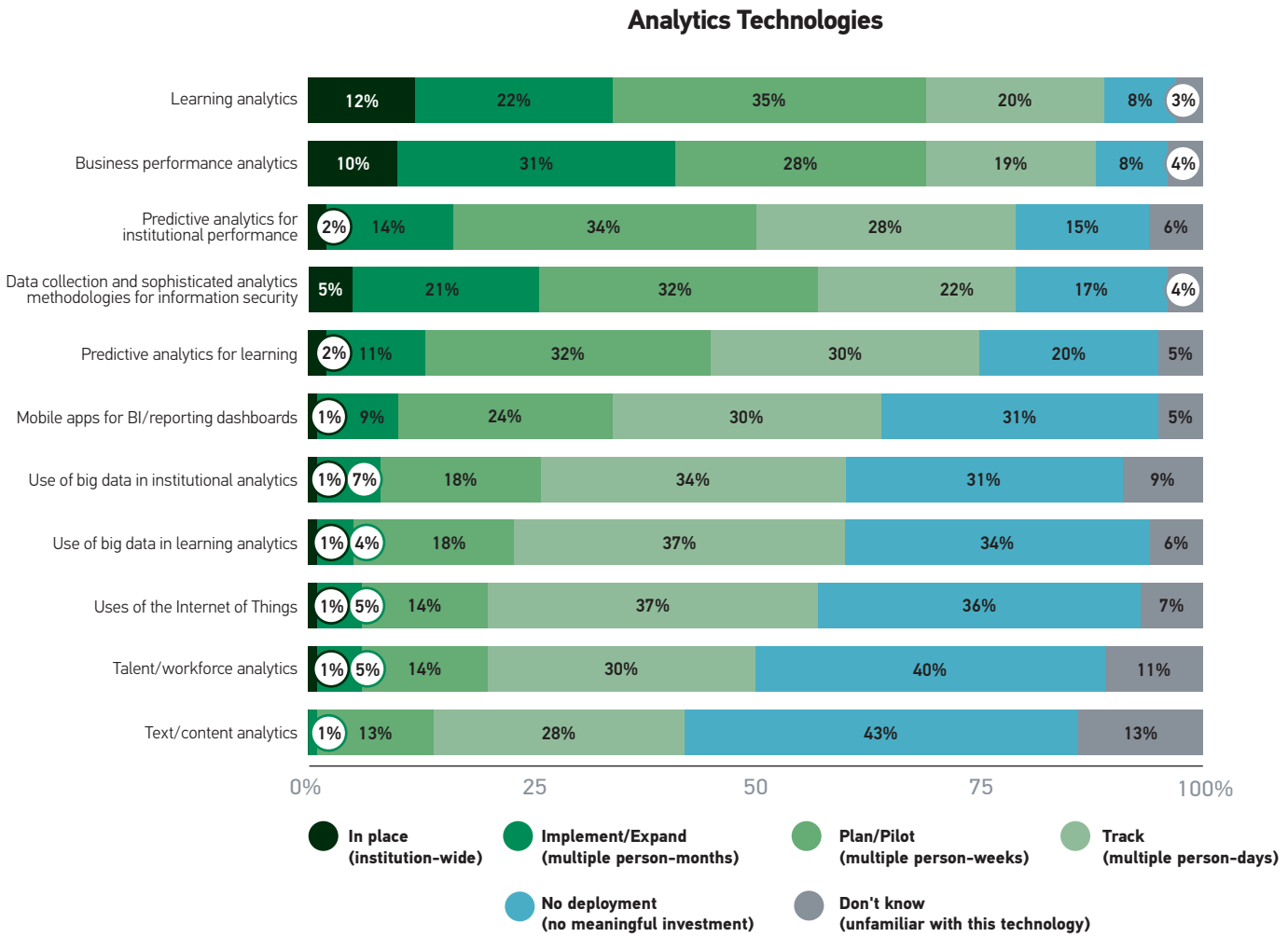
7. **Service desk tool and management strategy** has multiple components, depending on an institution's strategy. It may include sourcing decisions about the IT service desk tool and function (such as shared services, cloud sourcing, and outsourcing), adoption of ITSM-based (IT service management) process and service management frameworks, and tool selection and configuration.
8. **Learning analytics** is analytics intended to enhance or improve student success. It is the "field associated with deciphering trends and patterns from educational big data, or huge sets of student-related data, to further the advancement of a personalized, supportive system of higher education."[5]
9. **Data collection and sophisticated analytics methodologies for information security** are being integrated into security information, event management, and other tools to enable IT organizations to identify more threats more quickly, providing "actionable intelligence regarding their security posture."[6]
10. **Application performance monitoring** (**APM**) tools track the performance of applications in relation to end users' experiences as well as internal metrics (for example, for load and capacity) that may be leading indicators of future performance issues. Their goal is to automate tracking and improve the reliability of application performance.

Findings

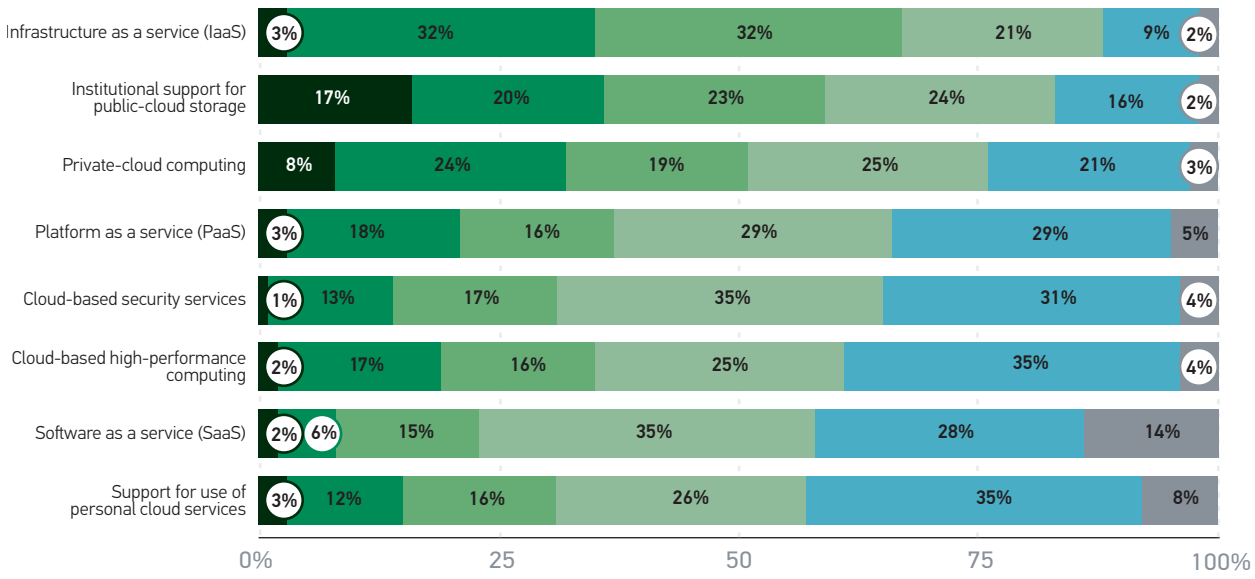
The top 10 strategic technologies were identified from a list of 83 technologies organized into 13 domain areas: analytics; cloud sourcing; communications/networking; devices; governance, risk, and compliance (GRC); identity and access management; infrastructure and operations; mobile; research and scholarship; security and privacy; social/personal; teaching and learning; and user support.

Some technologies were included in more than one domain. The figures on pages 10–20 summarize institutions' plans for the technologies within each domain.[7]

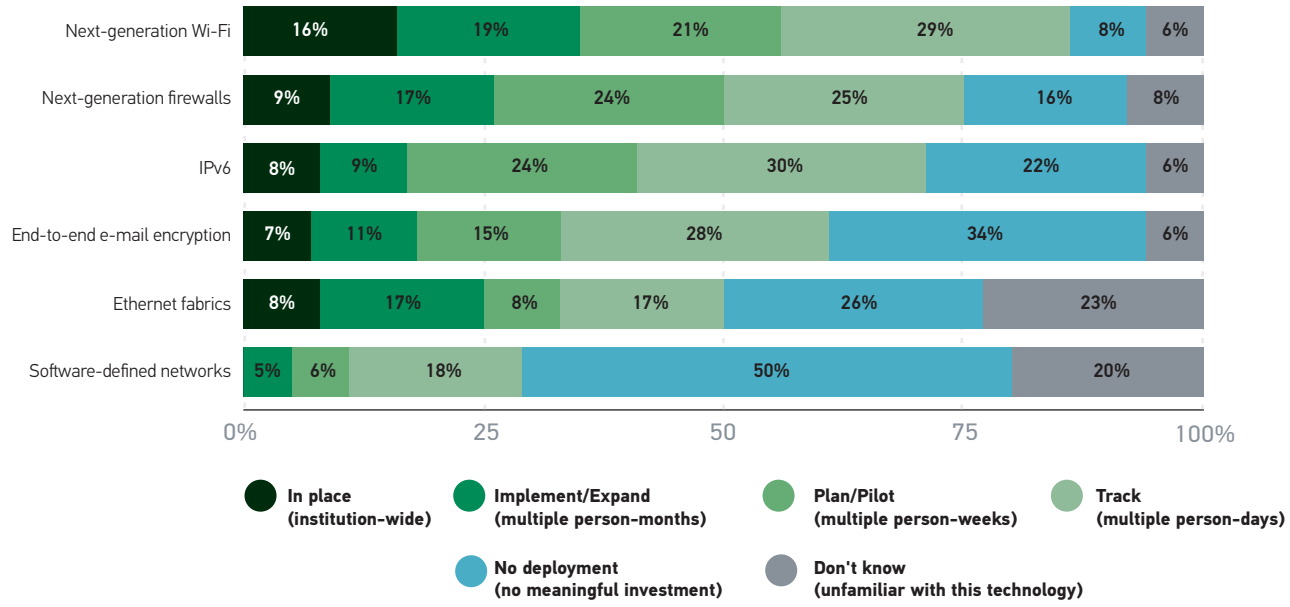
Higher Education's Technology Priorities for 2016

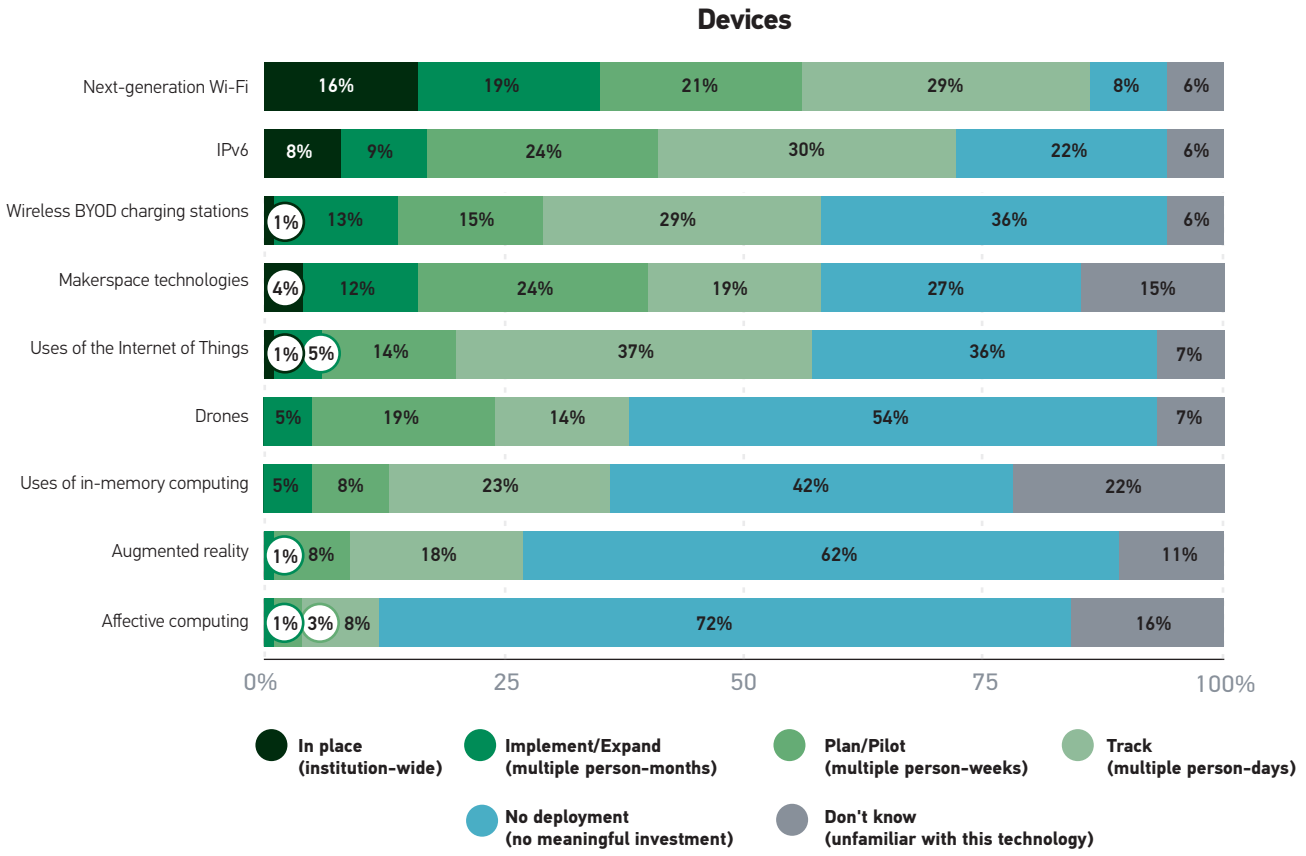


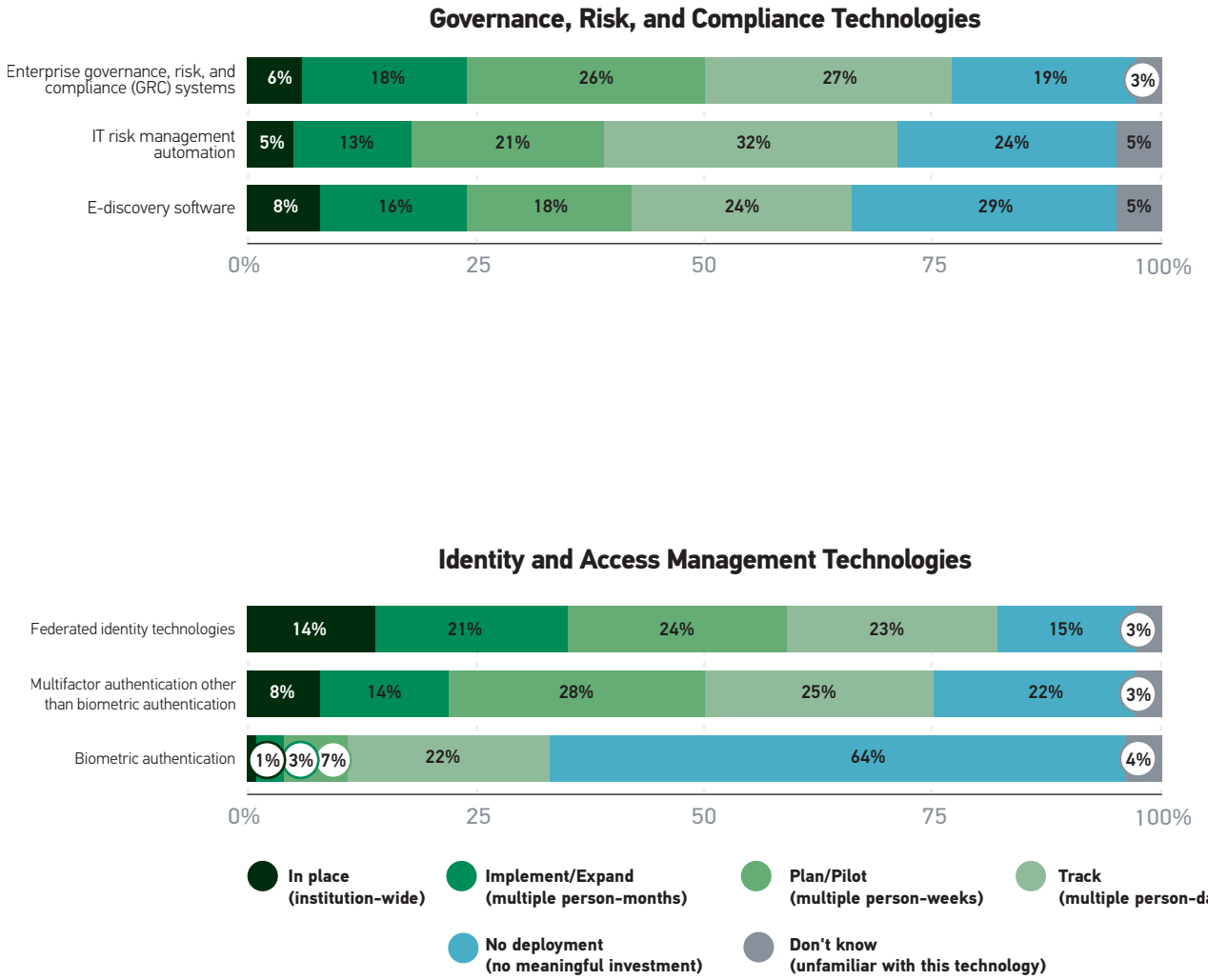
Cloud Technologies



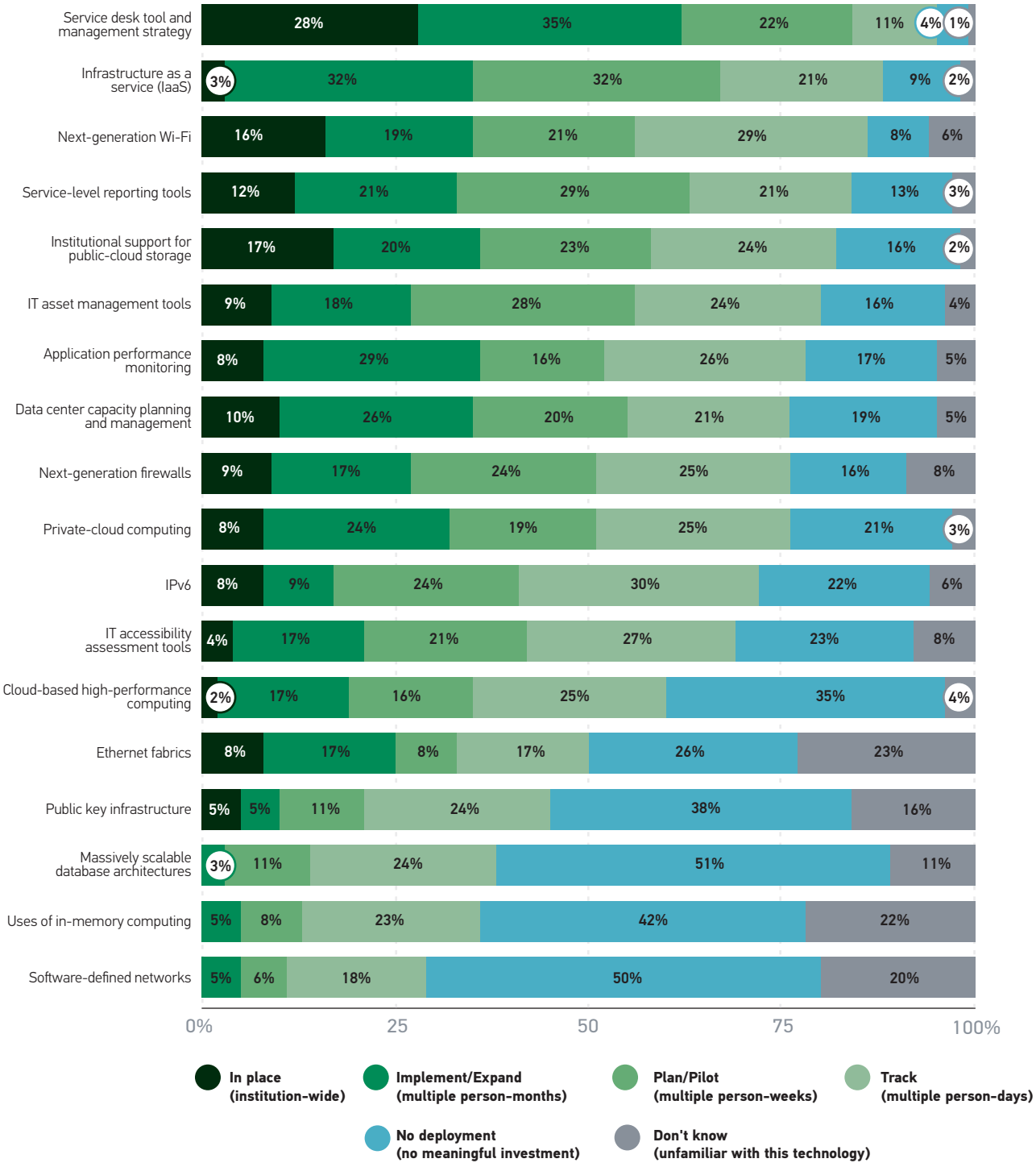
Communications/Networking Technologies

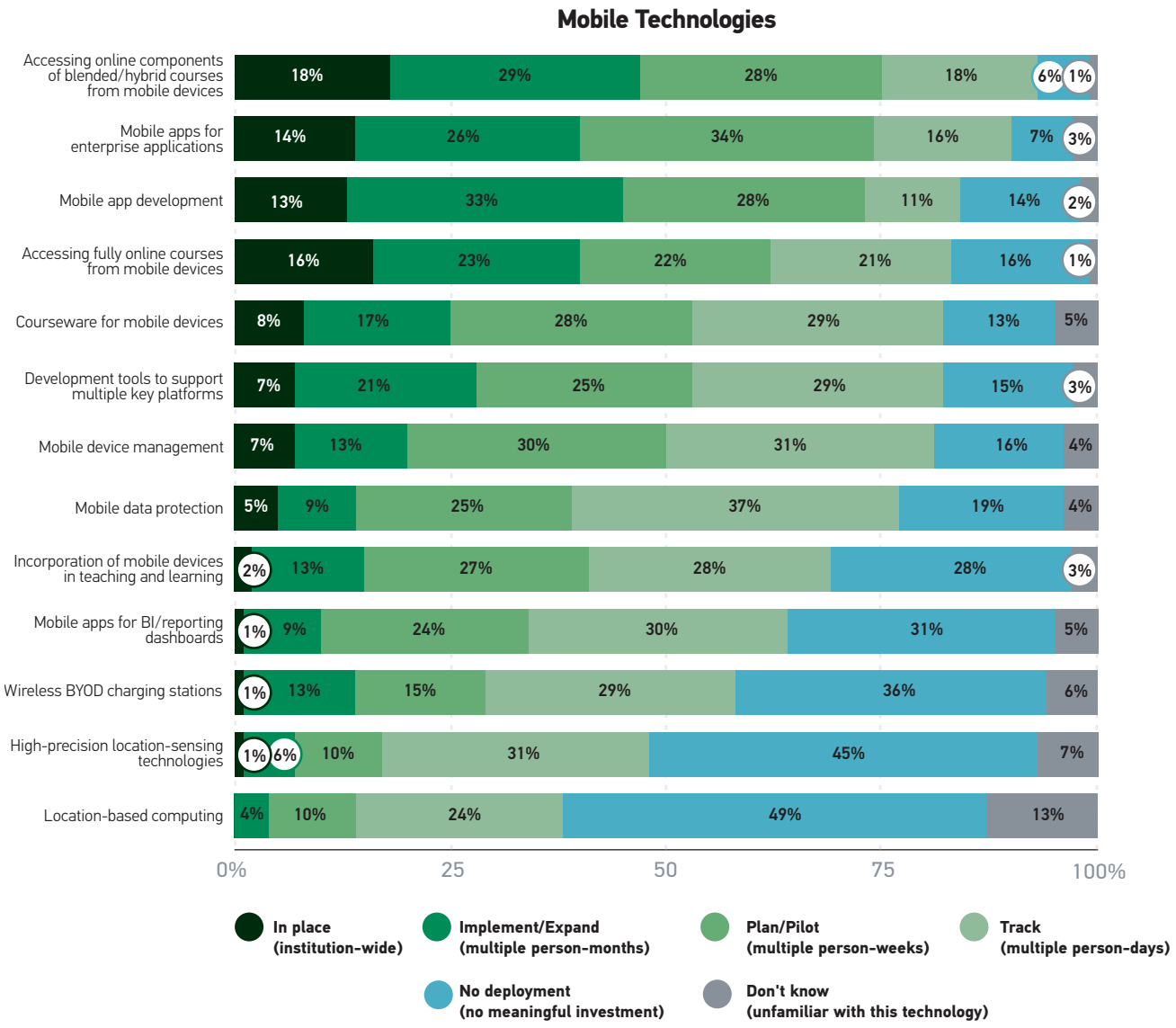


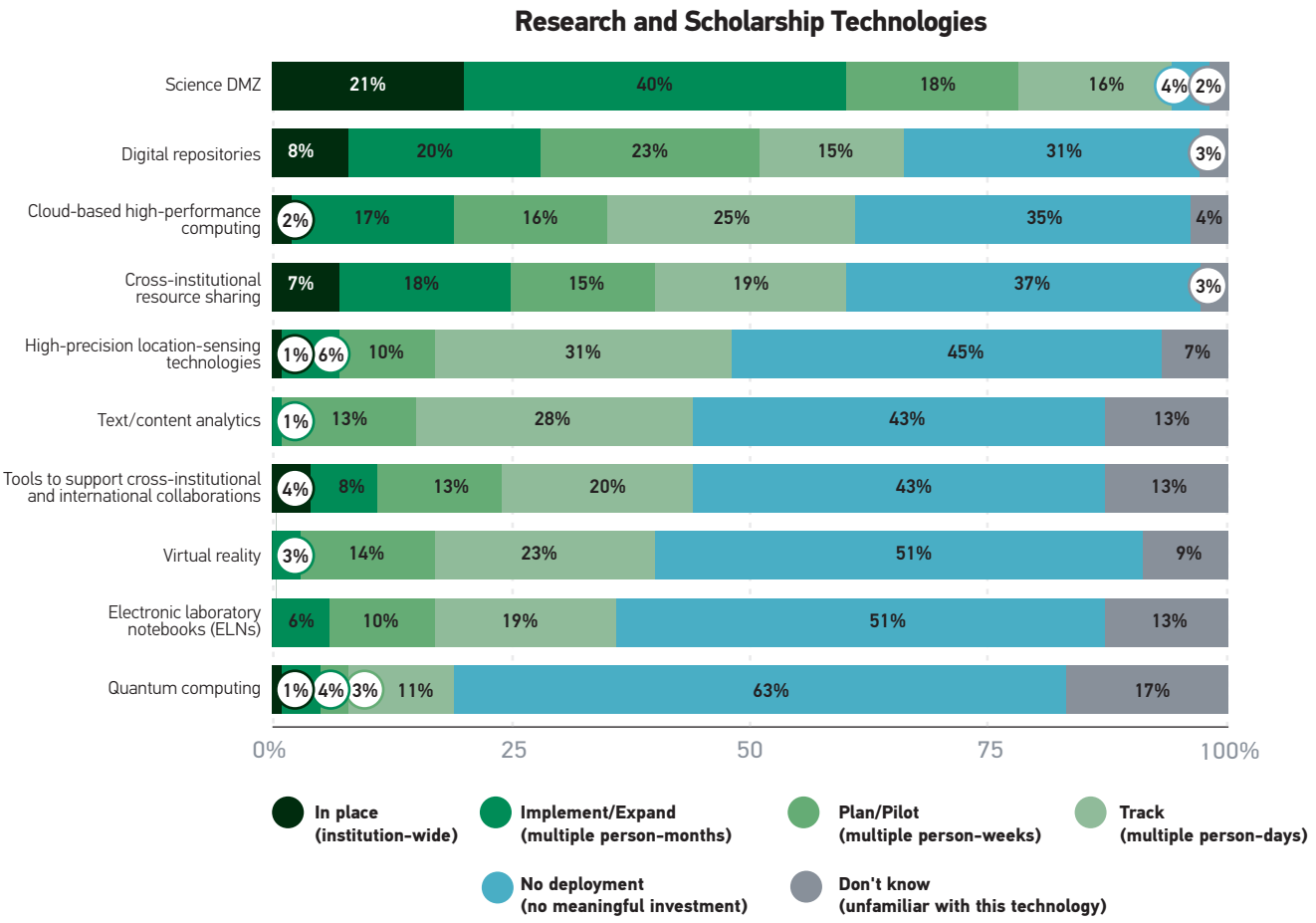

Devices
Next-generation Wi-Fi
16%
19%
21%
29%
8%
6%
IPv6
8%
9%
24%
30%
22%
6%
Wireless BYOD charging stations
1%
13%
15%
29%
36%
6%
Makerspace technologies
4%
12%
24%
19%
27%
15%
Uses of the Internet of Things
1%
5%
14%
37%
36%
7%
Drones
5%
19%
14%
54%
7%
Uses of in-memory computing
5%
8%
23%
42%
22%
Augmented reality
1%
8%
18%
62%
11%
Affective computing
1%
3%
8%
72%
16%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)

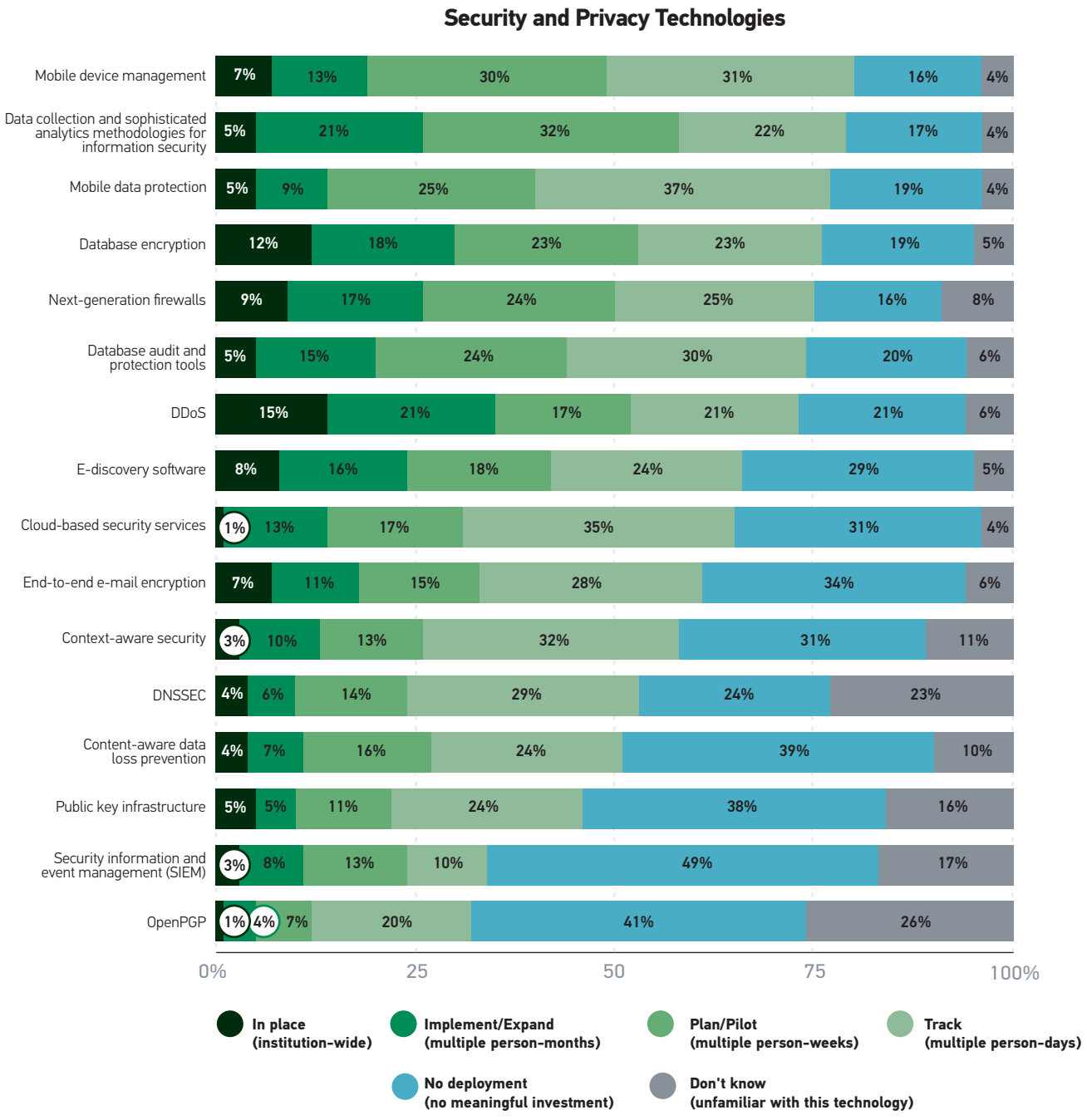

Governance, Risk, and Compliance Technologies
Enterprise governance, risk, and compliance (GRC) systems
6%
18%
26%
27%
19%
3%
IT risk management automation
5%
13%
21%
32%
24%
5%
E-discovery software
8%
16%
18%
24%
29%
5%
0%
25
50
75
100%
Identity and Access Management Technologies
Federated identity technologies
14%
21%
24%
23%
15%
3%
Multifactor authentication other than biometric authentication
8%
14%
28%
25%
22%
3%
Biometric authentication
1%
3%
7%
22%
64%
4%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)

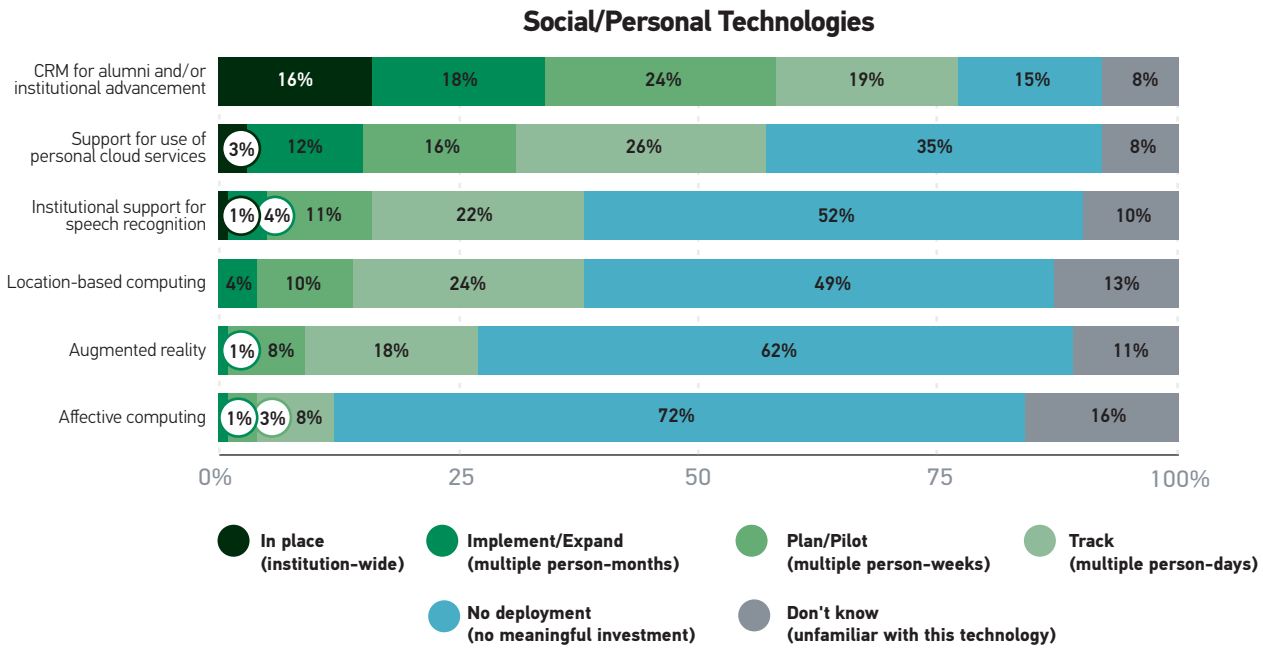
Infrastructure and Operations Technologies

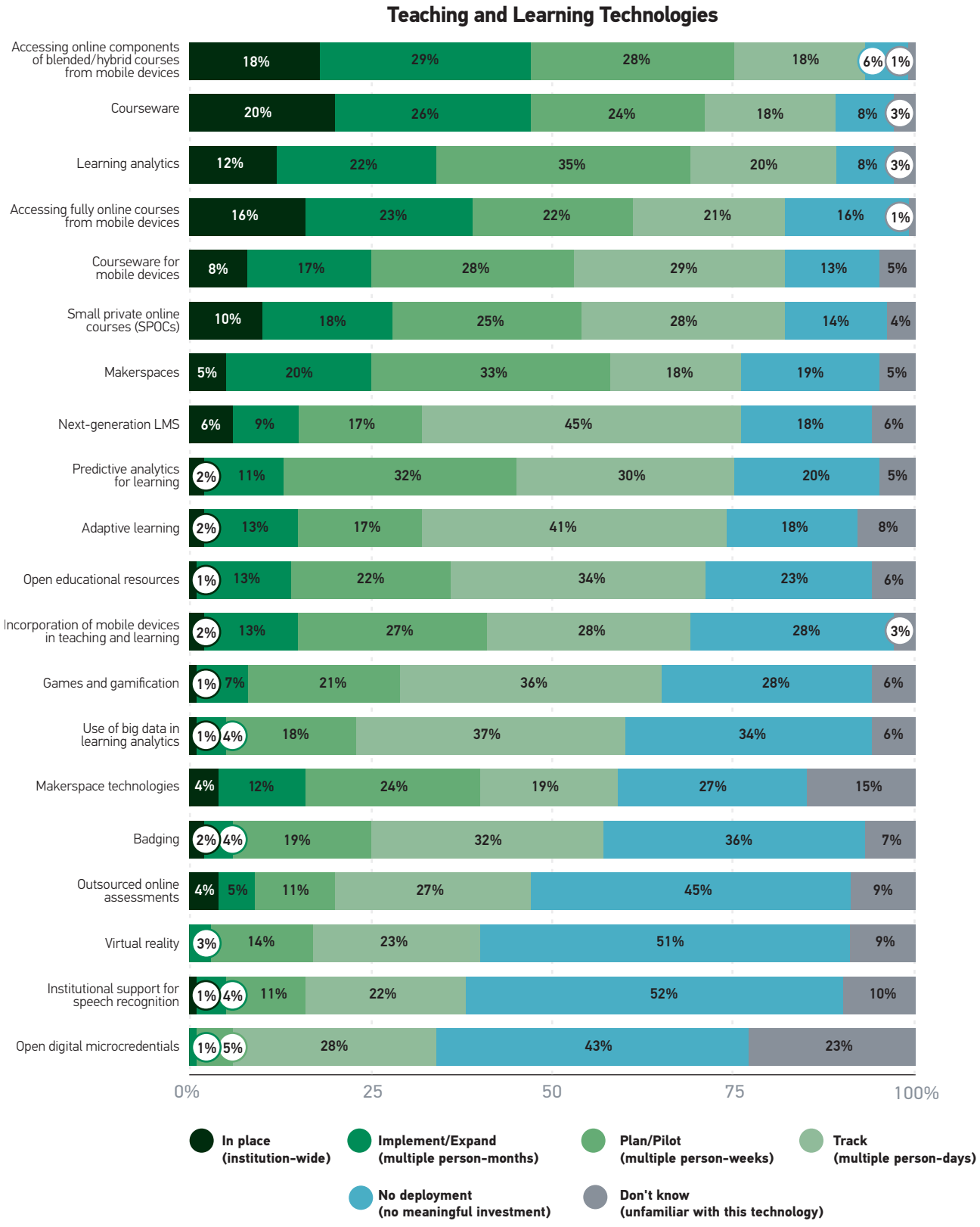


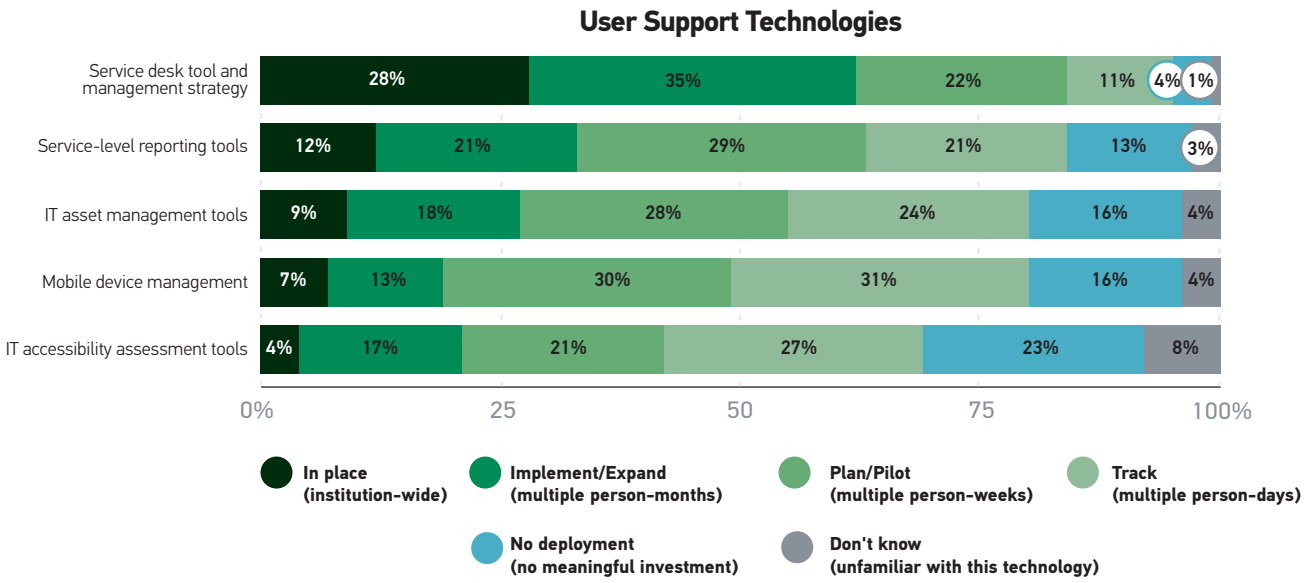

Mobile Technologies
Accessing online components of blended/hybrid courses from mobile devices
18%
29%
28%
18%
6%
1%
Mobile apps for enterprise applications
14%
26%
34%
16%
7%
3%
Mobile app development
13%
33%
28%
11%
14%
2%
Accessing fully online courses from mobile devices
16%
23%
22%
21%
16%
1%
Courseware for mobile devices
8%
17%
28%
29%
13%
5%
Development tools to support multiple key platforms
7%
21%
25%
29%
15%
3%
Mobile device management
7%
13%
30%
31%
16%
4%
Mobile data protection
5%
9%
25%
37%
19%
4%
Incorporation of mobile devices in teaching and learning
2%
13%
27%
28%
28%
3%
Mobile apps for BI/reporting dashboards
1%
9%
24%
30%
31%
5%
Wireless BYOD charging stations
1%
13%
15%
29%
36%
6%
High-precision location-sensing technologies
1%
6%
10%
31%
45%
7%
Location-based computing
4%
10%
24%
49%
13%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)


Research and Scholarship Technologies
Science DMZ
21%
40%
18%
16%
4%
2%
Digital repositories
8%
20%
23%
15%
31%
3%
Cloud-based high-performance computing
2%
17%
16%
25%
35%
4%
Cross-institutional resource sharing
7%
18%
15%
19%
37%
3%
High-precision location-sensing technologies
1%
6%
10%
31%
45%
7%
Text/content analytics
1%
13%
28%
43%
13%
Tools to support cross-institutional and international collaborations
4%
8%
13%
20%
43%
13%
Virtual reality
3%
14%
23%
51%
9%
Electronic laboratory notebooks (ELNs)
6%
10%
19%
51%
13%
Quantum computing
1%
4%
3%
11%
63%
17%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)


Security and Privacy Technologies
Mobile device management
7%
13%
30%
31%
16%
4%
Data collection and sophisticated analytics methodologies for information security
5%
21%
32%
22%
17%
4%
Mobile data protection
5%
9%
25%
37%
19%
4%
Database encryption
12%
18%
23%
23%
19%
5%
Next-generation firewalls
9%
17%
24%
25%
16%
8%
Database audit and protection tools
5%
15%
24%
30%
20%
6%
DDoS
15%
21%
17%
21%
21%
6%
E-discovery software
8%
16%
18%
24%
29%
5%
Cloud-based security services
1%
13%
17%
35%
31%
4%
End-to-end e-mail encryption
7%
11%
15%
28%
34%
6%
Context-aware security
3%
10%
13%
32%
31%
11%
DNSSEC
4%
6%
14%
29%
24%
23%
Content-aware data loss prevention
4%
7%
16%
24%
39%
10%
Public key infrastructure
5%
5%
11%
24%
38%
16%
Security information and event management (SIEM)
3%
8%
13%
10%
49%
17%
OpenPGP
1%
4%
7%
20%
41%
26%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)


Social/Personal Technologies
CRM for alumni and/or institutional advancement
16%
18%
24%
19%
15%
8%
Support for use of personal cloud services
3%
12%
16%
26%
35%
8%
Institutional support for speech recognition
1%
4%
11%
22%
52%
10%
Location-based computing
4%
10%
24%
49%
13%
Augmented reality
1%
8%
18%
62%
11%
Affective computing
1%
3%
8%
72%
16%
0%
25
50
75
100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)


Teaching and Learning Technologies
Accessing online components of blended/hybrid courses from mobile devices
18% 29% 28% 18% 6% 1%
Courseware
20% 26% 24% 18% 8% 3%
Learning analytics
12% 22% 35% 20% 8% 3%
Accessing fully online courses from mobile devices
16% 23% 22% 21% 16% 1%
Courseware for mobile devices
8% 17% 28% 29% 13% 5%
Small private online courses (SPOCs)
10% 18% 25% 28% 14% 4%
Makerspaces
5% 20% 33% 18% 19% 5%
Next-generation LMS
6% 9% 17% 45% 18% 6%
Predictive analytics for learning
2% 11% 32% 30% 20% 5%
Adaptive learning
2% 13% 17% 41% 18% 8%
Open educational resources
1% 13% 22% 34% 23% 6%
Incorporation of mobile devices in teaching and learning
2% 13% 27% 28% 28% 3%
Games and gamification
1% 7% 21% 36% 28% 6%
Use of big data in learning analytics
1% 4% 18% 37% 34% 6%
Makerspace technologies
4% 12% 24% 19% 27% 15%
Badging
2% 4% 19% 32% 36% 7%
Outsourced online assessments
4% 5% 11% 27% 45% 9%
Virtual reality
3% 14% 23% 51% 9%
Institutional support for speech recognition
1% 4% 11% 22% 52% 10%
Open digital microcredentials
1% 5% 28% 43% 23%
0% 25 50 75 100%
In place (institution-wide)
Implement/Expand (multiple person-months)
Plan/Pilot (multiple person-weeks)
Track (multiple person-days)
No deployment (no meaningful investment)
Don't know (unfamiliar with this technology)



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 2016 (see the Methodology section for more details). We tested for statistically significant institutional differences in attention scores by:

- Carnegie Classification: associate's, bachelor's, public master's, private master's, public doctoral, and private doctoral.
- Institutional size: fewer than 2,000 FTEs (faculty, staff, and 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 34% of respondents, mainstream 39%, and late adopters 27%.[8]

We found many institutional differences in attention scores, or the amount of attention respondents reported their institution would be paying to technologies. Not surprisingly, doctoral institutions (particularly private doctorals), larger institutions, and institutions that tend to adopt technology early are paying more attention to a number of technologies. But this pattern didn't always hold.

Carnegie Classification Differences

Associate's Institutions

Paying more attention than other types of institutions to:

- Accessing fully online courses from mobile devices
- Courseware (technology-supported teaching and learning materials)
- Distributed denial-of-service (DDoS) protection products and services
- Makerspace technologies (e.g., 3D printers and scanners, CNC [computer numerical control] machines)
- Mobile apps for enterprise applications
- Open educational resources
- Wireless BYOD charging stations

Paying less attention than other types of institutions to:

- Administrative or business performance analytics
- Cloud-based high-performance computing
- Content-aware DLP (data loss prevention)
- Cross-institutional resource sharing of research computing services
- Data collection and sophisticated analytics methodologies for information security
- Digital repositories for researchers and scholars
- IaaS
- PaaS
- Science DMZ
- Tools to support cross-institutional and international collaborations (e.g., Globus)

Bachelor's Institutions

Paying more attention than other types of institutions to:

- None

Paying less attention than other types of institutions to:

- Accessing fully online courses from mobile devices
- Accessing online components of blended/hybrid courses from mobile devices
- Adaptive learning
- Content-aware DLP (data loss prevention)
- Context-aware security
- Courseware (technology-supported teaching and learning materials)
- Courseware (technology-supported teaching and learning materials) for mobile devices
- Customer relationship management (CRM) for alumni and/or institutional advancement
- Data center capacity planning and management
- Data collection and sophisticated analytics methodologies
- Database audit and protection tools
- Distributed denial-of-service (DDoS) protection products and services
- DNSSEC (domain name system security extensions)
- E-discovery software to facilitate identification, preservation, and analysis of electronically stored information
- Ethernet fabrics
- Games and gamification
- High-precision location-sensing technologies (e.g., RFID, M2M, device clouds, smart meters, near field communication, iBeacon)
- Incorporation of mobile devices in teaching and learning
- IT accessibility assessment tools
- IT asset management tools (e.g., configuration management database [CMDB])
- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting

- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile apps for BI/reporting dashboards
- Mobile device management
- Next-generation learning management systems
- Open digital microcredentials
- Open educational resources
- Outsourced online assessments (third-party management of online assessments)
- PaaS
- Predictive analytics for institutional performance
- Predictive analytics for learning
- Private-cloud computing
- Service desk tool and management strategy
- Service-level reporting tools
- Security information and event management (SIEM)
- Talent/workforce analytics
- Use of big data in institutional analytics (mining massive amounts of structured and unstructured data)
- Use of big data in learning analytics (mining massive amounts of structured and unstructured data)
- Wireless BYOD charging stations

Public Master's Institutions

Paying more attention than other types of institutions to:

- Content-aware DLP (data loss protection)
- Data center capacity planning and management
- Data collection and sophisticated analytics methodologies for information security

Paying less attention than other types of institutions to:

- Distributed denial-of-service (DDoS) protection products and services
- Games and gamification
- IaaS

- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile app development
- Mobile apps for enterprise applications
- Open educational resources
- Outsourced online assessments (third-party management of online assessments)
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)

Private Master's Institutions

Paying more attention than other types of institutions to:

- None

Paying less attention than other types of institutions to:

- Cloud-based high-performance computing
- Cross-institutional resource sharing of research computing services
- Data collection and sophisticated analytics methodologies for information security
- Database audit and protection tools
- Database encryption
- Digital repositories for researchers and scholars
- End-to-end e-mail encryption
- Enterprise governance, risk, and compliance (GRC) systems
- Federated identity technologies (e.g., OAuth, OpenID)
- Games and gamification
- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting
- Makerspaces
- Makerspace technologies (e.g., 3D printers and scanners, CNC [computer numerical control] machines)
- Mobile app development (responsive design, hybrid, etc.)
- Mobile apps for enterprise applications
- Security information and event management (SIEM)
- Text/content analytics

- Tools to support cross-institutional and international collaborations (e.g., Globus)
- Uses of in-memory computing
- Uses of the Internet of Things (wearable technology support, wireless smart objects, etc.)

Public Doctoral Institutions

Paying more attention than other types of institutions to:

- Cross-institutional resource sharing of research computing services
- Development tools to support multiple key platforms (e.g., Windows, Android, iOS) and application architectures (e.g., native, hybrid, and mobile web)
- Digital repositories for researchers and scholars
- DNSSEC (domain name system security extensions)
- Federated identity technologies (e.g., OAuth, OpenID)
- Games and gamification
- IT accessibility assessment tools
- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile app development (responsive design, hybrid, etc.)
- Mobile apps for BI/reporting dashboards
- Multifactor authentication other than biometric authentication
- Open educational resources
- PaaS
- Science DMZ
- Tools to support cross-institutional and international collaborations (e.g., Globus)

Paying less attention than other types of institutions to:

- Cloud-based security services
- Institutional support for public-cloud storage
- SaaS

Private Doctoral Institutions

Paying more attention than other types of institutions to:

- Accessing fully online courses from mobile devices
- Adaptive learning
- Administrative or business performance analytics
- Application performance monitoring
- Augmented reality (digitally enhanced physical objects)
- Biometric authentication
- Cloud-based high-performance computing
- Cloud-based security services
- Content-aware DLP (data loss prevention)
- Context-aware security
- Courseware (technology-supported teaching and learning materials)
- CRM for alumni and/or institutional advancement
- Data center capacity planning and management
- Data collection and sophisticated analytics methodologies for information security
- Database audit and protection tools
- Database encryption
- Distributed denial-of-service (DDoS) protection products and services
- Digital repositories for researchers and scholars
- Electronic laboratory notebooks (ELNs)
- End-to-end e-mail encryption
- Federated identity technologies
- Games and gamification
- High-precision location-sensing technologies (e.g., RFID, M2M, device clouds, smart meters, near field communication, iBeacon)
- IaaS
- Incorporation of mobile devices in teaching and learning
- Institutional support for public-cloud storage
- IPv6

- IT accessibility assessment tools
- IT asset management tools (e.g., CMDB)
- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting
- Learning analytics
- Makerspaces
- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile apps for BI/reporting dashboards
- Mobile apps for enterprise applications
- Mobile data protection
- Mobile device management
- Next-generation learning management systems
- OpenPGP
- Outsourced online assessments (third-party management of online assessments)
- PaaS
- Predictive analytics for learning
- Private-cloud computing
- Quantum computing
- Science DMZ
- Service-level reporting tools
- Software-defined networks
- SPOCs (small private online courses)
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)
- Support for use of personal cloud services
- Talent/workforce analytics
- Text/content analytics
- Tools to support cross-institutional and international collaborations (e.g., Globus)
- Use of big data in institutional analytics (mining massive amounts of structured and unstructured data)

- Use of big data in learning analytics (mining massive amounts of structured and unstructured data)
- Uses of in-memory computing
- Uses of the Internet of Things (wearable technology support, wireless smart objects, etc.)
- Virtual reality

Paying less attention than other types of institutions to:

- None

Institutional Size Differences

Size matters. Although larger institutions do not necessarily have more IT financial or staffing resources per student or per institutional FTE, they do have larger organizations and therefore specialized staff who can focus on specific projects and technologies.

Larger institutions are paying more attention than smaller institutions to 42% of the technologies on our list:

- Biometric authentication
- Cloud-based high-performance computing
- Content-aware DLP (data loss prevention)
- Cross-institutional resource sharing of research computing services
- Data collection and sophisticated analytics methodologies for information security
- Database audit and protection tools
- Development tools to support multiple key platforms (e.g., Windows, Android, iOS) and application architectures (e.g., native, hybrid, and mobile web)
- Digital repositories for researchers and scholars
- Games and gamification
- High-precision location-sensing technologies (e.g., RFID, M2M, device clouds, smart meters, near field communication, iBeacon)
- IaaS
- IPv6
- IT accessibility assessment tools

- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting
- Location-based computing/institutional use of location intelligence
- Makerspace technologies (e.g., 3D printers and scanners, CNC [computer numerical control] machines)
- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile apps for BI/reporting dashboards
- Multifactor authentication other than biometric authentication
- Open educational resources
- PaaS
- Predictive analytics for institutional performance
- Predictive analytics for learning
- Private-cloud computing
- Science DMZ
- Software-defined networks
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)
- Support for use of personal cloud services
- Talent/workforce analytics
- Text/content analytics
- Tools to support cross-institutional and international collaborations (e.g., Globus)
- Use of big data in institutional analytics (mining massive amounts of structured and unstructured data)
- Use of big data in learning analytics (mining massive amounts of structured and unstructured data)
- Uses of in-memory computing
- Wireless BYOD charging stations

With mobile app development, we found that the smallest (fewer than 2,000 FTEs) and the largest (15,000+ FTEs) were paying significantly more attention than all other sized institutions. We found a similar pattern last year.

Differences Related to Approach to Technology Adoption

We found numerous differences in the attention institutions are paying to the technologies when we tested attention against approach to technology adoption. Institutions whose respondents described their institutional approach to technology adoption as earlier than others tend to pay more attention to 52% of the technologies than self-described mainstream adopters, who pay more attention than those identifying as late adopters. Technology adoption stance is not a proxy for institutional type: Early, mainstream, and late adopters were roughly equally distributed within each Carnegie class.

Late and mainstream adopters are spending more time on learning analytics than early adopters. In one additional instance—mobile apps for enterprise applications—mainstream adopters are spending significantly more time than late or early adopters. In both cases, this is probably because more early adopters have already widely deployed these technologies.

Competitive advantage? Early adopters are spending more time than late adopters with:

- Accessing fully online courses from mobile devices
- Accessing online components of blended/hybrid courses from mobile devices
- Adaptive learning
- Augmented reality (digitally enhanced physical objects)
- Badging
- Biometric authentication
- Cloud-based high-performance computing
- Cloud-based security services
- Courseware (technology-supported teaching and learning materials)
- Courseware (technology-supported teaching and learning materials) for mobile devices
- Cross-institutional resource sharing of research computing services
- Database audit and protection tools
- Development tools to support multiple key platforms (e.g., Windows, Android, iOS) and application architectures (e.g., native, hybrid, and mobile web)
- Digital repositories for researchers and scholars
- Drones
- E-discovery software to facilitate identification, preservation, and analysis of electronically stored information

- Electronic laboratory notebooks (ELNs)
- Enterprise governance, risk, and compliance (GRC) systems
- High-precision location-sensing technologies (e.g., RFID, M2M, device clouds, smart meters, near field communication, iBeacon)
- IaaS
- Incorporation of mobile devices in teaching and learning
- IPv6
- IT asset management tools (e.g., CMDB)
- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting
- Location-based computing
- Makerspaces
- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Mobile apps for BI/reporting dashboards
- Mobile data protection
- Multifactor authentication other than biometric authentication
- Next-generation learning management systems
- Open educational resources
- PaaS
- Software-defined networks
- Talent/workforce analytics
- Text/content analytics
- Tools to support cross-institutional and international collaborations (e.g., Globus)
- Use of big data in institutional analytics (mining massive amounts of structured and unstructured data)
- Use of big data in learning analytics (mining massive amounts of structured and unstructured data)
- Uses of in-memory computing
- Uses of the Internet of Things (wearable technology support, wireless smart objects, etc.)
- Virtual reality
- Wireless BYOD charging stations

Institutional Differences by Technology Domains

The appendix shows how technologies were grouped into 13 domains: analytics, cloud sourcing, communications/networking, devices, GRC, identity and access management, infrastructure and operations, mobile, research and scholarship, security and privacy, social/personal, teaching and learning, and user support.

All institutional types except associate's and private doctorals are devoting the most attention to the domain of user support technologies. The highest priority among associate's institutions is the domain of GRC technologies. Public doctorals and the largest institutions (15,000+ FTEs) are also devoting a lot of their attention to these technologies. Private doctorals are devoting particular attention to cloud sourcing technologies.

Social/personal technologies are receiving the least attention among all institutional types except associate's institutions. Associate's institutions are paying less attention to research and scholarship technologies than to other domains. For late adopters, devices are receiving less attention than other domains except social/personal.

Private doctorals are paying more attention than other institutional types to all technology domains, with two exceptions: GRC and identity and access management technologies. The largest institutions (15,000+ FTEs) are paying the most attention of all institutional types to GRC, and public doctorals to identity and access management technologies.

Bachelor's institutions are devoting less attention than all other institutional types to 9 of the 13 domains (the exceptions are devices, identity and access management, research and scholarship, and social/personal). Private master's institutions are devoting the least attention of all institutional types to devices, research and scholarship, and social/personal.

Institutional differences also clearly appear when we look at the top 10 technologies for each of the institutional types we examined, as shown in the Top 10 Technologies by Carnegie class figure. The figure lists the top 10 technologies by Carnegie class (some institutional types have more than 10 because of numerous ties) and also depicts the magnitude of attention institutions are paying to each technology by placing technologies in one of two groups to show whether institutions, on average, are only tracking or planning the technology (less attention) or are piloting or deploying it (more attention).

Top 10 Technologies by Carnegie Class

	AA	BA	MA PUBLIC
PILOTING–DEPLOYING	1. Mobile devices in teaching and learning 2. Makerspace technologies* 2. Mobile apps for enterprise systems*		1. SaaS
TRACKING–PLANNING	4. Courseware* 4. Mobile access to hybrid courses* 6. Mobile access to fully online courses 7. Application performance monitoring* 7. Mobile app development* 9. Courseware for mobile devices* 9. DDoS* 9. Learning analytics* 9. SaaS* 9. Service desk tool and mgmt. strategy*	1. SaaS 2. Business performance analytics 3. Digital repositories* 3. Mobile app development* 3. Mobile devices in teaching and learning* 3. Learning analytics* 7. Mobile apps for enterprise systems* 7. Multiplatform development tools* 9. Makerspace technologies* 9. Mobile access to hybrid courses*	2. Analytics for information security 3. Business performance analytics* 3. Mobile access to hybrid courses* 5. Data center capacity planning and mgmt. 6. Learning analytics* 6. Service desk tool and mgmt. strategy* 6. Mobile access to fully online courses* 9. Mobile devices in teaching and learning* 9. Next-generation firewalls* 9. Predictive analytics for institutional perf.* 9. Service-level reporting tools*

	MA PRIVATE	DR PUBLIC	DR PRIVATE
PILOTING–DEPLOYING		1. Mobile app development 2. Mobile devices in teaching and learning 3. Cross-institutional resource sharing	1. Business performance analytics 2. Analytics for information security 3. Mobile apps for enterprise systems 4. IaaS* 4. Mobile devices in teaching and learning* 4. Private-cloud computing* 7. IT asset management tools* 7. Learning analytics* 9. Cloud-based HPC* 9. Digital repositories*
TRACKING–PLANNING	1. Service desk tool and mgmt. strategy 2. Mobile access to hybrid courses 3. SaaS 4. Mobile devices in teaching and learning 5. Business performance analytics* 5. Public-cloud storage support* 7. Courseware 8. Mobile access to fully online courses* 8. Mobile device management* 10. Learning analytics* 10. Multiplatform development tools*	4. Mobile apps for enterprise systems* 4. Multiplatform development tools* 6. Multifactor authentication other than biometric authentication 7. Digital repositories* 7. Federated identity technologies* 7. Makerspace technologies* 7. Mobile access to hybrid courses* 7. Predictive analytics for institutional perf.*	

* Indicates a tie

Only one technology in the overall top 10 appeared among the top 10 of every institutional type: incorporation of mobile devices in teaching and learning. Business performance analytics was almost as universal. It was missing only from the top 10 of public doctorals, ranking as the 23rd technology among those institutions. Two technologies—application performance monitoring, and data collection and sophisticated analytics methodologies for information security—appeared in the top 10 lists of only half the institutional types. The top 10 technologies of public doctorals diverged most from the overall top 10 list: Six of the overall top 10 were not among the public doctoral top 10.

The figure clearly shows that private doctorals are investing more attention in their top 10 than any other group, and bachelors and masters institutions are investing the least.

What We Don't Yet Broadly Understand

Quite a few respondents indicated they were unfamiliar with particular technologies. The 10 least familiar technologies included three security-related, three research-related, two teaching and learning, and two infrastructure technologies:

1. OpenPGP (26% unfamiliar) is a nonproprietary e-mail encryption protocol that can be used to exchange encrypted messages and files among individuals within and across institutions. OpenPGP can also secure files stored on mobile devices or in the cloud.[9]
2. DNSSEC (23%). The Domain Name System (DNS) is a hierarchical distributed naming system that translates domain names (e.g., educause.edu) to IP addresses. DNSSEC is a set of security extensions to DNS that can help authenticate DNS names and thus protect against forged or manipulated DNS data. It does not encrypt or otherwise protect data confidentiality.
3. Ethernet fabric (23%) is a network topology that "is aware of all its paths, nodes, requirements and resources."[10] Ethernet fabrics can scale very easily (up or down), facilitating performance, and are becoming more common as data centers become increasingly virtualized and cloud-based.
4. Open digital microcredentials (23%) refer to the attainment, documentation, and exchange of digital credentials that represent skills, competencies, and accomplishments. Badging is the most notable but not the only form of microcredential. Open credentials are meant to be nonproprietary and portable.[11]

5. In-memory computing (22%) "helps make big-data analytics possible by keeping data in a server's RAM rather than removing it to databases on separate disk drives." The data can be "retained in its original format," and it can also be "searched, found, retrieved, and processed at much higher rates than data kept on disks."[12]
6. SPOCs (20%) are small private online courses, or an emerging alternative to MOOCs (massive online open courses).[13] Designed to be local rather than global, a SPOC is intended to enhance campus-based courses to "enable professors to more fully engage a targeted group of learners, who benefit in turn from an intensive, personal course setting."[14]
7. Quantum computing (17%) applies quantum mechanics to computation. It transcends the zero/one bit-based models of computation by using quantum bits, which can additionally work with "superpositions" of ones and zeros. This vastly increases the possible number of simultaneous calculations and enables tasks and computations that were previously out of reach. Currently, quantum computing's primary relevance to higher education is in research.[15]
8. Science DMZ (17%) "provides a network-architecture approach 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."[16]
9. Public key infrastructure (PKI) (16%) supports secure data exchange and authentication over the Internet via the distribution and identification of public encryption keys. PKI generally includes "hardware, software, policies and standards to manage the creation, administration, distribution and revocation of keys and digital certificates."[17]
10. Affective computing (16%) refers to computing in relation to affects, or emotions. It includes technologies that can recognize as well as those that can influence emotions.[18]

Implications

What do these data tell us about the kinds of progress higher education might make with the technologies measured in this study?

Where Are We Heading and How Fast?

We used institutions' 2016 intentions for implementing and planning technologies to estimate deployment of these technologies within two years (2017–18) and five years (2019–21).

The figures on pages 38–43 provide progress estimates for the individual technologies within the 13 technology domains. Almost half of the technologies (35) were assigned to two domains, and five technologies were assigned to three domains. The figures depict the estimates for when each technology and domain are 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)

We predict that among the 83 technologies, only service desk tool and management strategies will achieve universal adoption within the next five years. Ten other technologies will enter the mainstream by then:

- Accessing fully online courses from mobile devices
- Accessing online components of blended/hybrid courses from mobile devices
- Business performance analytics
- Courseware
- Incorporation of mobile devices in teaching and learning
- Learning analytics
- Mobile app development
- Mobile apps for enterprise applications
- SaaS
- Service-level reporting tools

Two of the three technologies in the top 10 currently classified as experimental—data collection and sophisticated analytics methodologies for information security, and application performance monitoring—will achieve growing adoption (deployed in 41–60% of institutions) within five years.

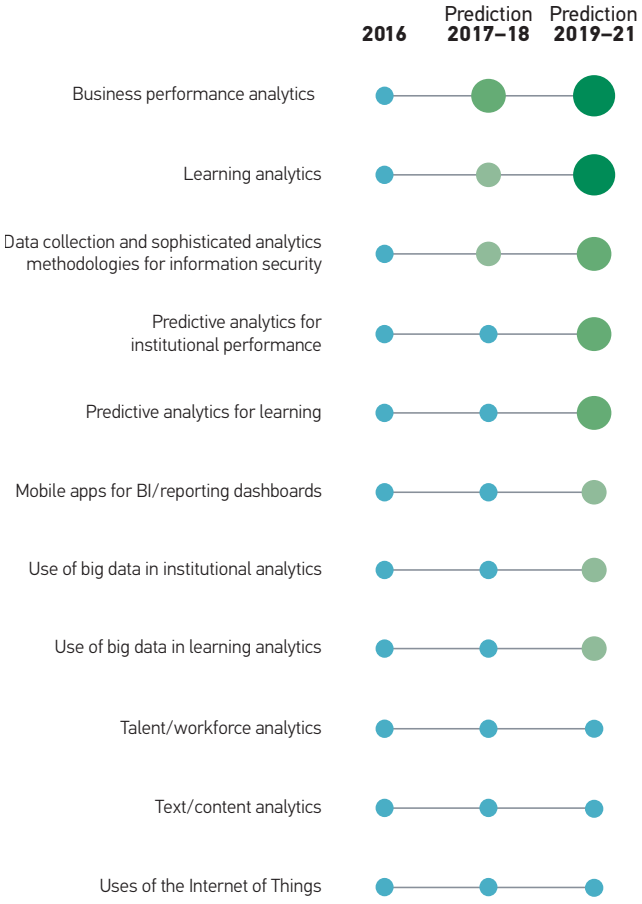
We identified 23 additional technologies outside the top 10 that are also rapidly increasing (as defined by a predicted five-year increase in institution-wide deployment of 40 percentage points or more):

Technology	Today	By 2021
Accessing fully online courses from mobile devices	Experimental	Mainstream
Courseware	Experimental	Mainstream
Service-level reporting tools*	Experimental	Mainstream
Courseware for mobile devices	Experimental	Growing
CRM for alumni and/or institutional advancement	Experimental	Growing
Data center capacity planning and management	Experimental	Growing
Database encryption	Experimental	Growing
Development tools to support multiple key platforms	Experimental	Growing
Digital repositories	Experimental	Growing
Enterprise GRC systems	Experimental	Growing
Federated identity technologies	Experimental	Growing
IaaS	Experimental	Growing
Institutional support for public-cloud storage	Experimental	Growing
IT asset management tools	Experimental	Growing
Makerspace technologies*	Experimental	Growing
Mobile device management*	Experimental	Growing
Multifactor authentication other than biometric authentication	Experimental	Growing
Next-generation firewalls	Experimental	Growing
Next-generation Wi-Fi	Experimental	Growing
Predictive analytics for institutional performance*	Experimental	Growing
Predictive analytics for learning*	Experimental	Growing
Private-cloud computing	Experimental	Growing
Security information and event management (SIEM)	Experimental	Growing

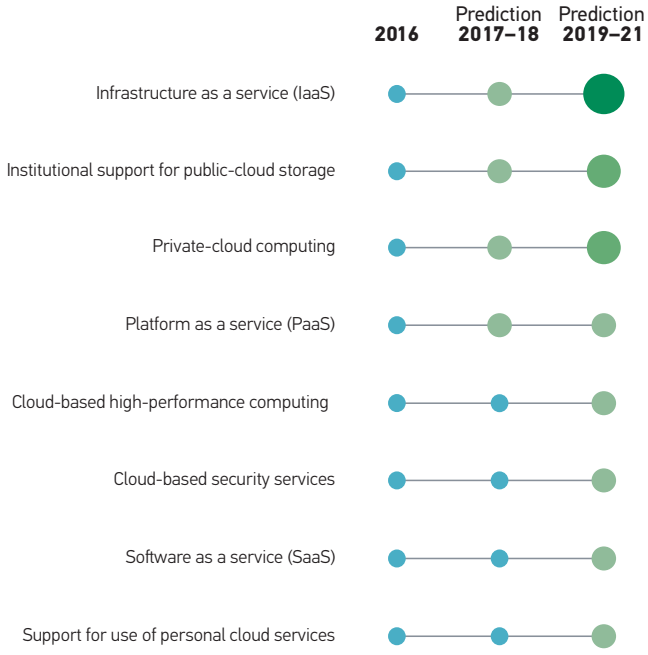
**One of the top 10 technologies on which institutions intend to spend planning time in 2016*

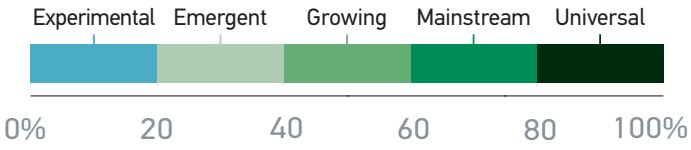
Estimated Five-Year Adoption Trends

Analytics Technologies

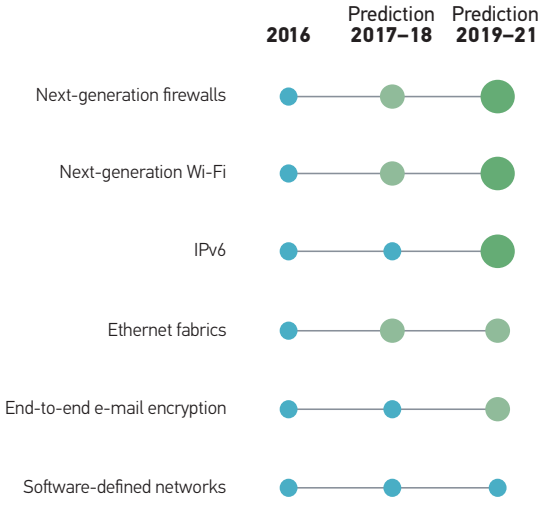


Cloud Technologies

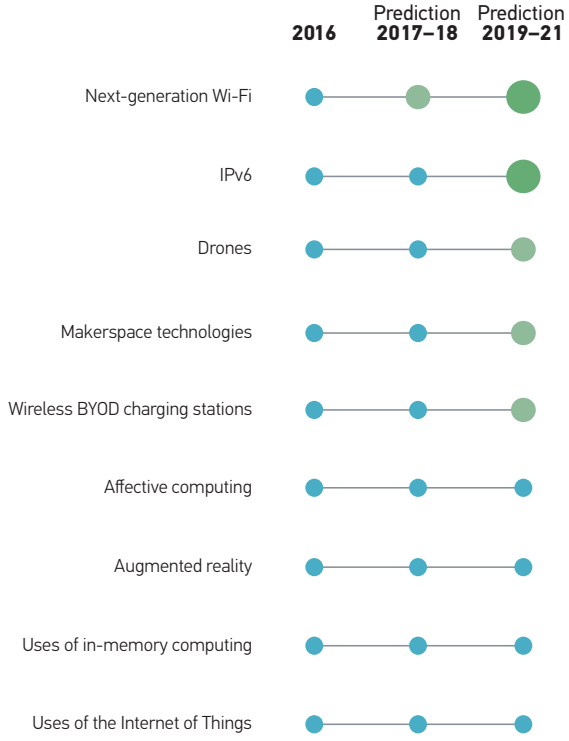


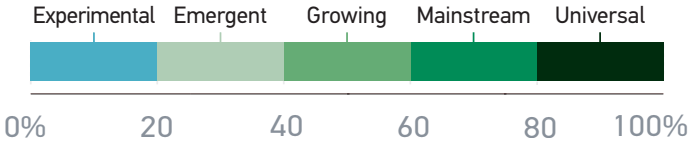


Communication/Networking Technologies

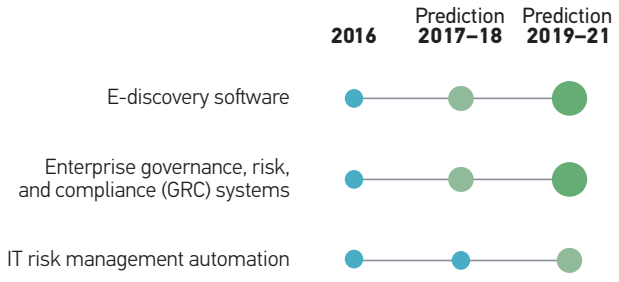


Devices

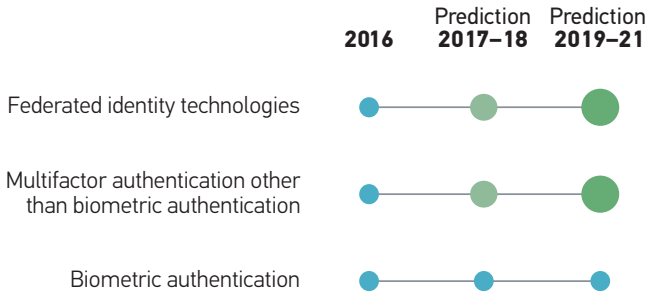


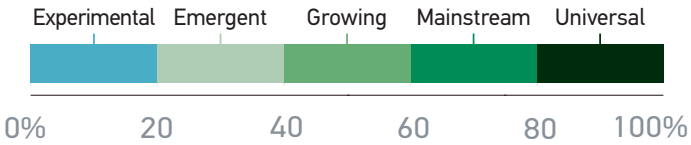


Governance, Risk, and Compliance Technologies

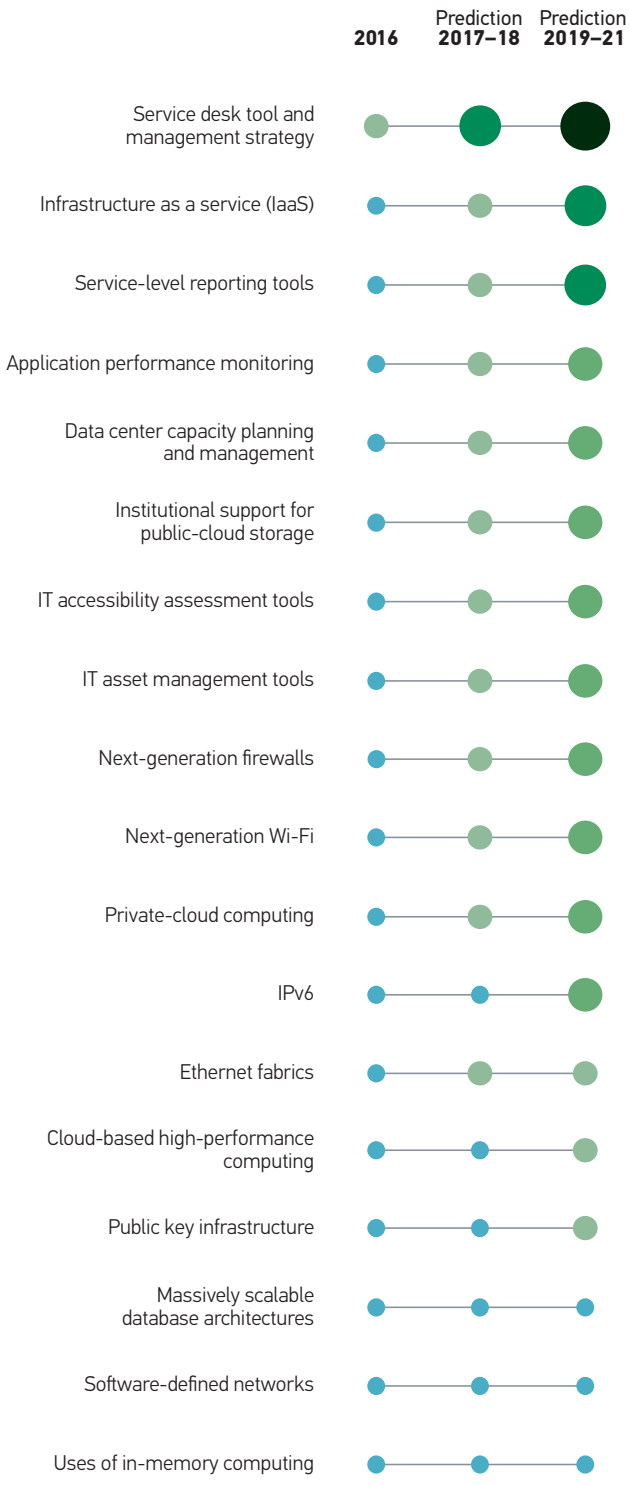


Identity and Access Management Technologies

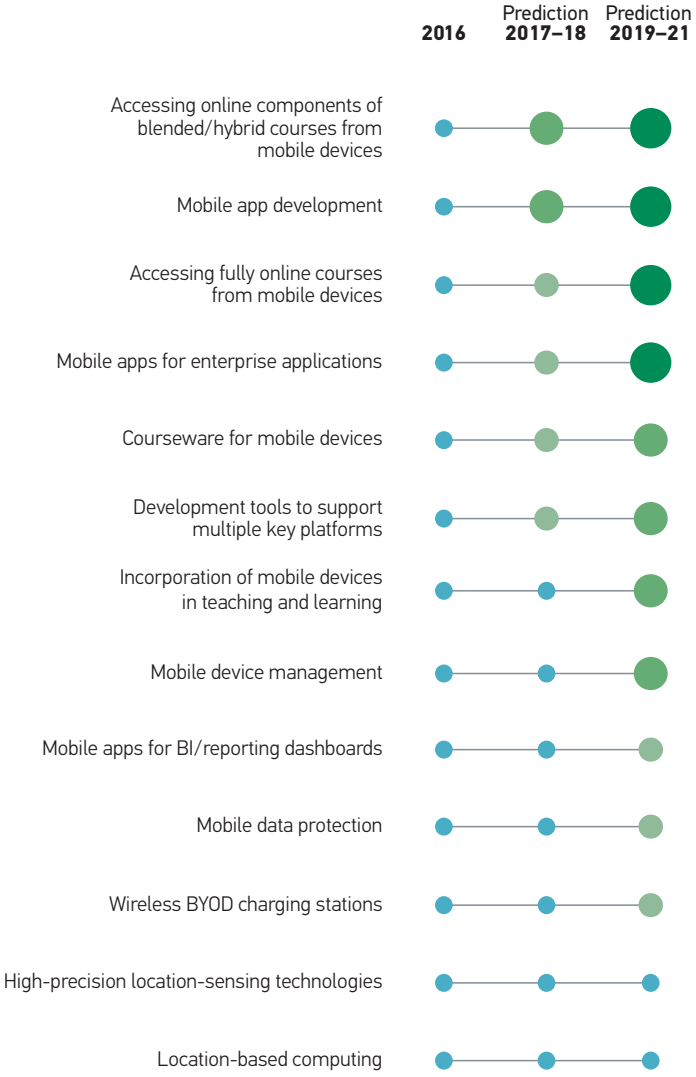


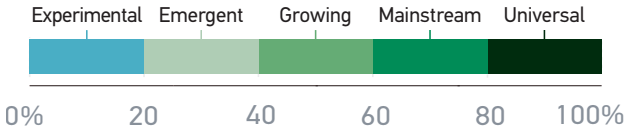


Infrastructure and Operations Technologies

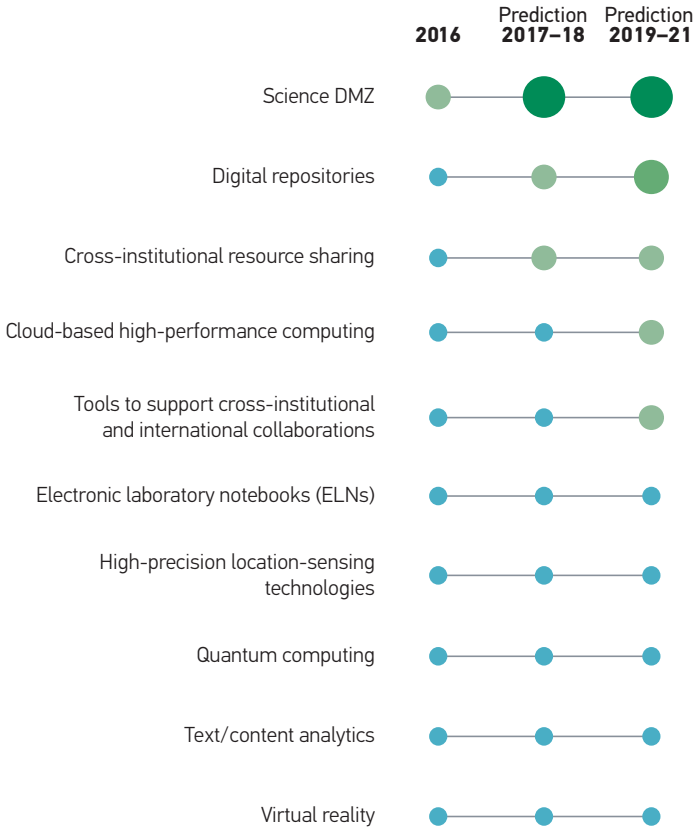


Mobile Technologies

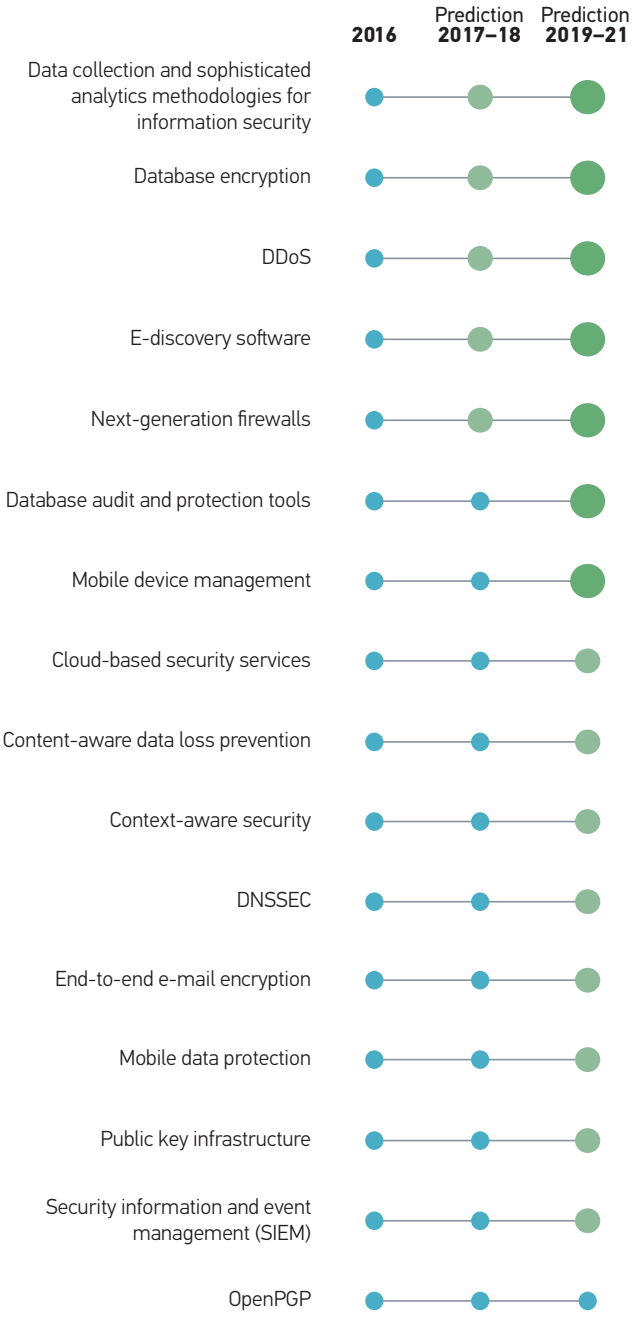


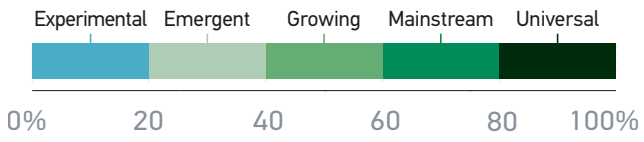


Research and Scholarship Technologies

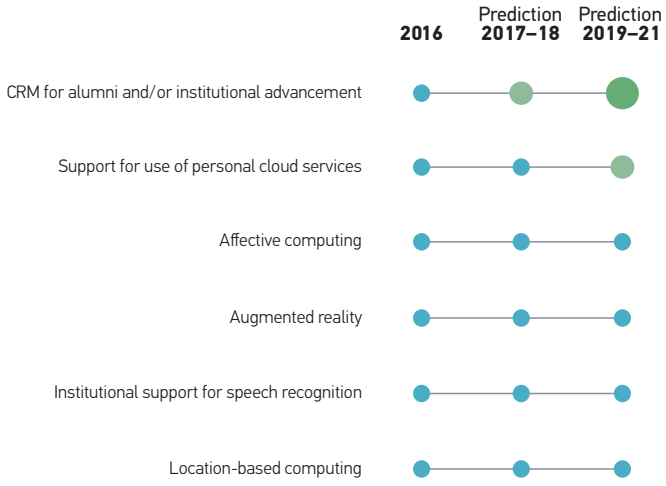


Security and Privacy Technologies

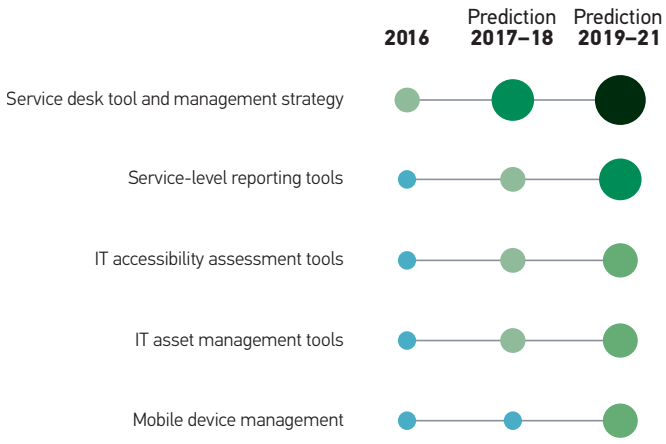




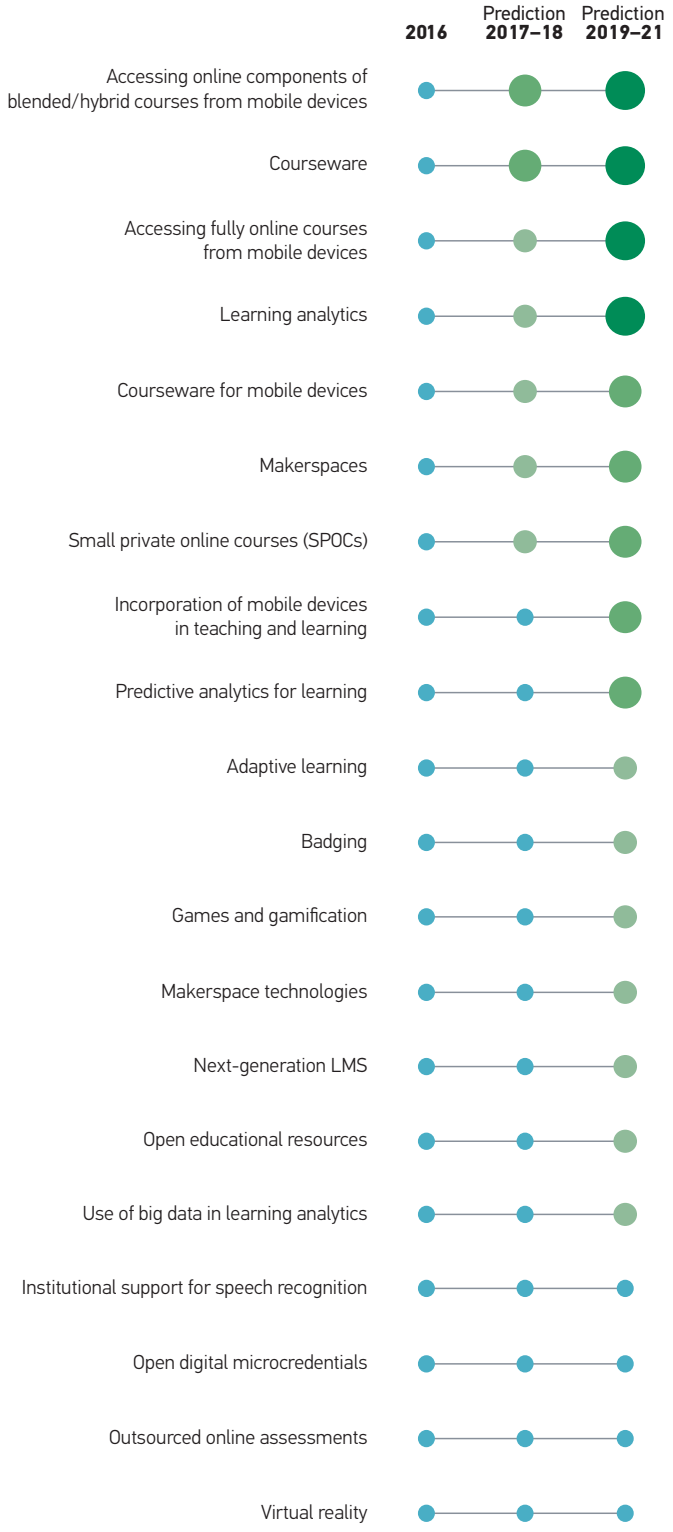
Social/Personal Technologies

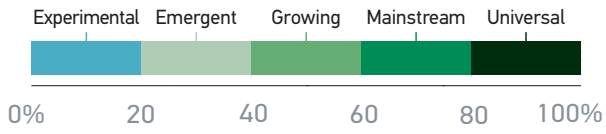


User Support Technologies

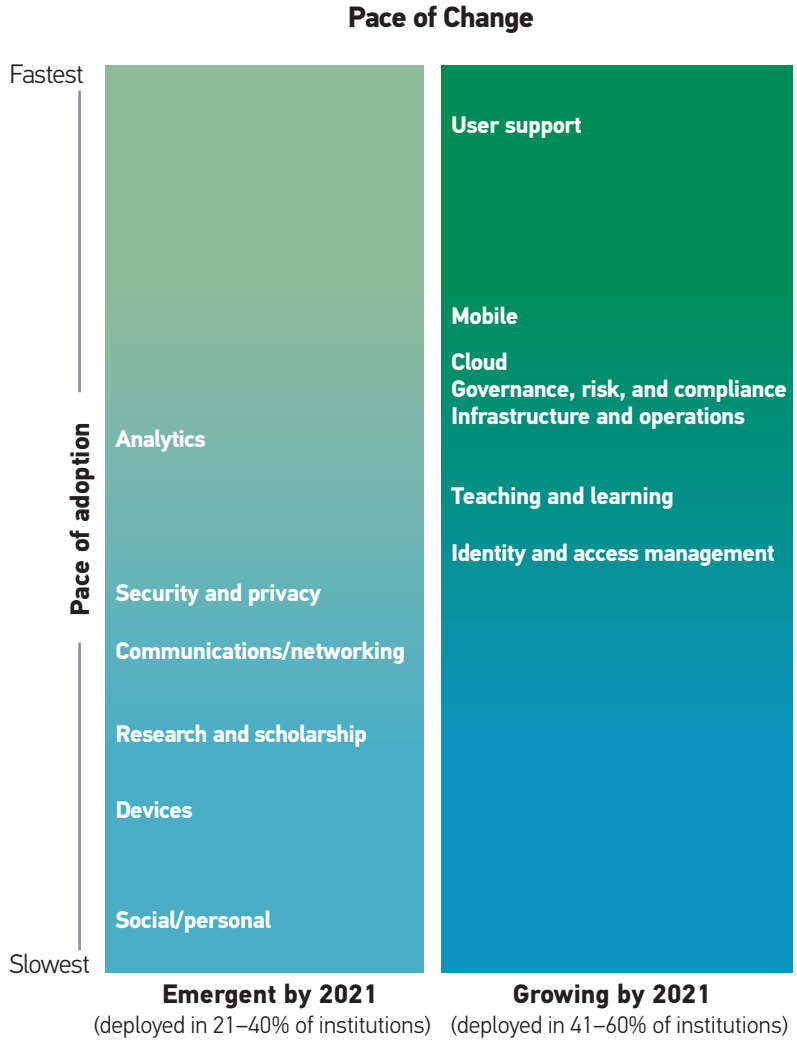


Teaching and Learning Technologies





The Pace of Change figure compares the pace of adoption among the 13 technology domains. The domain whose technologies we predict will make the most progress (as measured by percentage-point increases in adoption) over the next five years is user support, followed by mobile, cloud, GRC, and infrastructure and operations.



Advice

This list 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.

Learn

- Become familiar with the top 10 strategic technologies, the up-and-coming technologies (see the sidebar), and the technologies in each domain that are receiving the most attention in 2016.
- Understand how each technology does or does not fit your IT architecture, speed of adoption, and strategic directions.
- Read the EDUCAUSE 2016 Top 10 IT Issues article,[19] which identifies three themes that are highly pertinent to technology strategies:
  - **Divesting** of locally optimized and delivered technologies, architectures, and processes and moving to standardized and cloud-based services and architectures
  - **Reinvesting** in key areas to ensure readiness to manage a re-architected IT function and support mission differentiation with IT
  - **Using IT as a strategic differentiator** to enhance the institution's particular culture, missions, and strategies, particularly in analytics and in teaching and learning
- Consider the changes to service management, sourcing, budgeting, and the IT organization that may be needed to accommodate technology divestments and reinvestments and differentiating technologies.

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. At least 30% of institutions are tracking these 20 technologies in 2016:

1. Next-generation LMSs (45% tracking)
2. Adaptive learning (41%)
3. Mobile data protection (37%)
4. Use of big data in learning analytics (37%)
5. Uses of the Internet of Things (37%)
6. Games and gamification (36%)
7. Cloud-based security services (35%)
8. Software-defined networks (35%)
9. Open educational resources (34%)
10. Use of big data in institutional analytics (34%)
11. IT risk management automation (32%)
12. Context-aware security (32%)
13. Badging (32%)
14. Mobile device management (31%)
15. High-precision location-sensing technologies (31%)
16. Predictive analytics for learning (30%)
17. Database audit and protection tools (30%)
18. IPv6 (30%)
19. Mobile apps for BI/reporting dashboards (30%)
20. Talent/workforce analytics (30%)

Benchmark

- Compare your progress with that of others. Determine whether your institution is moving quickly enough to keep pace with technology advances and opportunities.
- Find peer role models and communities of practice to help you understand how best to introduce and deploy the technologies most relevant to your institution.
- Identify the technologies whose adoption you may need to accelerate, and determine why.

Lead

- Use this report, the Top 10 IT Issues report, and the *Trend Watch* report to brief leadership at your institution.
- Initiate discussions and reviews of institutional strategic plans to consider whether the institution is investing in the differentiating technologies that will be key to its future and whether it is moving quickly enough to cloud-based services and architectures.
- Take a risk-management approach: Will your institution's current technology and plans reduce or increase institutional risk in the coming years?
- Convene and collaborate with key institutional partners (e.g., finance, procurement, HR, distributed IT, student success) to shape a collective understanding of the implications of and needs for the IT organization's changing and new technology investments.

Acknowledgments

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

Methodology

The list of 83 technologies was derived from the 2015 list and from several authoritative sources that annually identify emerging and maturing technologies in higher education.[20] The ECAR Working Group Strategies Committee and EDUCAUSE staff who lead program areas (ELI, ECAR working groups, ECAR research, Cybersecurity, and Enterprise IT) reviewed the list and augmented and edited it. Several technologies on the 2015 list were removed. Some were eliminated because they were obscure, becoming irrelevant as technologies and practices continue to evolve, or still too nascent in higher education to warrant inclusion (e.g., virtual assistants, autonomic computing). Some technologies were redundant with Core Data Service content or were widespread enough based on the 2015 research to exceed our threshold of existing institutional deployment at no more than 30% of institutions. We refactored other technologies to make them clearer or more in keeping with evolving practices. Even so, the list could be improved. We reexamine it annually.

The survey was distributed to 10,140 EDUCAUSE members as part of the Top 10 IT Issues survey, with two reminders sent. Both reminder e-mails contained an error in the survey link. Although corrections were sent, it is likely this accounted for a 34% lower respondent group (243 members vs. 368 for 2015).

Respondents indicated the attention their institution was planning to devote to each technology in 2016. 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 2016.
- **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 2016, 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.

Because the list was so long (and to minimize "don't know" responses), respondents were given the option of identifying the technology domains for which they are responsible and responding only to items within those domains. Further, if several members from a single institution completed the survey, only one rating was included (we used the CIO as the primary rater). As a result, the number of respondents rating individual technologies ranged from 206 to 243.

The final top 10 list of strategic technologies 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.

Complete List of Technologies, Organized by Domain

Note: *The domains are not mutually exclusive. Almost half of the technologies (35) were assigned to two domains, and five technologies were assigned to three domains.*

Analytics

- Administrative or business performance analytics
- Data collection and sophisticated analytics methodologies for information security
- Learning analytics
- Mobile apps for BI/reporting dashboards
- Predictive analytics for institutional performance
- Predictive analytics for learning
- Talent/workforce analytics
- Text/content analytics
- Use of big data in institutional analytics (mining massive amounts of structured and unstructured data)
- Use of big data in learning analytics (mining massive amounts of structured and unstructured data)
- Uses of the Internet of Things (wearable technology support, wireless smart objects, etc.)

Cloud Sourcing

- Cloud-based high-performance computing
- Cloud-based security services
- IaaS (infrastructure as a service)
- Institutional support for public-cloud storage
- PaaS (platform as a service)
- Private-cloud computing
- SaaS (software as a service)
- Support for use of personal cloud services

Communications/Networking

- End-to-end e-mail encryption
- Ethernet fabrics
- IPv6
- Next-generation firewalls
- Software-defined networks
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)

Devices

- Affective computing (systems and devices that can recognize, interpret, process, and simulate emotion)
- Augmented reality (digitally enhanced physical objects)
- Drones
- IPv6
- Makerspace technologies (e.g., 3D printers and scanners, CNC [computer numerical control] machines)
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)
- Uses of in-memory computing
- Uses of the Internet of Things (wearable technology support, wireless smart objects, etc.)
- Wireless BYOD charging stations

Governance, Risk, and Compliance

- E-discovery software
- Enterprise governance, risk, and compliance (GRC) systems
- IT risk management automation to manage risk assessment, incident management, and compliance mapping/reporting

Identity and Access Management

- Biometric authentication
- Other multifactor authentication (e.g., security tokens, PINs, out-of-band mobile authentications) for critical applications
- Federated identity technologies (e.g., OAuth, OpenID)

Infrastructure and Operations

- Application performance monitoring
- Cloud-based high-performance computing
- Data center capacity planning and management tools
- Ethernet fabrics
- IaaS (infrastructure as a service)
- Institutional support for public-cloud storage
- IPv6
- IT accessibility assessment tools
- IT asset management tools (e.g., CMDB)
- Massively scalable database architectures (e.g., NoSQL, Hadoop)
- Next-generation firewalls
- Private-cloud computing
- Service desk tool and management strategy
- Service-level reporting tools
- Software-defined networks
- Support for next-generation Wi-Fi standards (802.11ad, af, and ah)
- Uses of in-memory computing

Mobile

- Accessing fully online courses from mobile devices
- Accessing online components of blended/hybrid courses from mobile devices
- Courseware (technology-supported teaching and learning materials) for mobile devices
- Development tools to support multiple key platforms (e.g., Windows, Android, iOS) and application architectures (e.g., native, hybrid, and mobile web)
- High-precision location-sensing technologies (e.g., RFID, M2M, device clouds, smart meters, near field communication, iBeacon)
- Incorporation of mobile devices in teaching and learning
- Location-based computing
- Mobile app development (responsive design, hybrid, etc.)
- Mobile apps for BI/reporting dashboards
- Mobile apps for enterprise applications
- Mobile data protection
- Mobile device management
- Wireless BYOD charging stations

Research and Scholarship

- Cloud-based high-performance computing
- Cross-institutional resource sharing of research computing services
- Digital repositories for researchers and scholars
- Electronic laboratory notebooks (ELNs)
- High-precision location-sensing technologies
- Quantum computing for researchers
- Science DMZ
- Text/content analytics
- Tools to support cross-institutional and international collaborations (e.g., Globus)
- Virtual reality

Security and Privacy

- Cloud-based security services
- Content-aware DLP (data loss prevention)
- Context-aware security
- Data collection and sophisticated analytics methodologies for information security
- Database audit and protection tools
- Database encryption
- Distributed denial-of-service protection products and services (DDoS)
- DNSSEC (domain name system security extensions)
- E-discovery software to facilitate identification, preservation, and analysis of electronically stored information
- End-to-end e-mail encryption
- Mobile data protection
- Mobile device management
- Next-generation firewalls
- OpenPGP
- Public key infrastructure (PKI)
- Security information and event management (SIEM)

Social/Personal

- Affective computing (systems and devices that can recognize, interpret, process, and simulate emotion)
- Augmented reality (digitally enhanced physical objects)
- CRM for alumni and/or institutional advancement
- Institutional support for speech recognition
- Location-based computing/institutional use of location intelligence
- Support for use of personal cloud services

Teaching and Learning

- Accessing fully online courses from mobile devices
- Accessing online components of blended/hybrid courses from mobile devices
- Adaptive learning
- Badging
- Courseware (technology-supported teaching and learning materials)
- Courseware (technology-supported teaching and learning materials) for mobile devices
- Games and gamification
- Incorporation of mobile devices in teaching and learning
- Institutional support for speech recognition
- Learning analytics
- Makerspaces
- Makerspace technologies (e.g., 3D printers and scanners, CNC [computer numerical control] machines)
- Next-generation learning management systems
- Open digital microcredentials
- Open educational resources
- Outsourced online assessments (third-party management of online assessments)
- Predictive analytics for learning
- SPOCs (small private online courses)
- Use of big data in learning analytics
- Virtual reality

User Support

- IT accessibility assessment tools
- IT asset management tools (e.g., CMDB)
- Mobile device management
- Service desk tool and management strategy
- Service-level reporting tools

Notes

1. EDUCAUSE Core Data Service.
2. EDUCAUSE program staff and member leaders helped select and word the 83 technologies. Participants included leaders of the EDUCAUSE Learning Initiative (ELI), the Higher Education Information Security Council (HEISC), the Enterprise IT Program, Core Data Service, and members of the ECAR Working Group Strategies Committee. This group identified technologies to add, technologies to retire because they were no longer relevant, and technologies to move into the Core Data Service because they were already deployed in more than 30% of institutions. They also helped word and group technologies.
3. Susan Grajek and the 2014–2015 EDUCAUSE IT Issues Panel, "The Top 10 IT Issues 2015: Inflection Point," *EDUCAUSE Review* 50, no. 1 (January/February 2015).
4. Susan Grajek and Betsy Tippens Reinitz, *Trend Watch 2015: Influential IT Directions in Higher Education*, research report (Louisville, CO: ECAR, March 23, 2015).
5. L. Johnson, S. Adams Becker, M. Cummins, V. Estrada, A. Freeman, and H. Ludgate, *Horizon Report: 2013 Higher Education Edition* (Austin, Texas: The New Media Consortium, 2013).
6. Fran Howarth, "Improving Security Management with Advanced Analytic Techniques," RSA, October 20, 2014.
7. All values in the charts are rounded to the nearest whole number.
8. Respondents were asked to indicate their institution's preferred overall approach to adopting technology and given five response options:
   - We are usually among the very first to adopt new technologies.
   - We strive to be early adopters of new technologies where we see exceptional benefits.
   - We tend to adopt new technologies at the pace of our peers.
   - We tend to adopt new technologies after our peers do so.
   - We are one of the last to adopt new technologies.
9. See the Open PGP Alliance and Pretty Good Privacy, *Wikipedia*.
10. See Ethernet Fabric, *Techopedia*.
11. Tara Garcia Mathewson, "Micro-Credentials Open Higher Ed to Those Looking to Broaden Skills," *Education Dive*, September 30, 2015.
12. ECAR, "In-Memory Computing: ECAR-WG Technology Spotlight," research bulletin (Louisville, CO: ECAR, August 14, 2015).
13. Malcolm Brown, "Moving Into the Post-MOOC Era," July 29, 2103.
14. Stephanie Garlock, "Is Small Beautiful?" *Harvard Magazine*, July-August 2015.
15. Christopher Packham, "Researchers Take Two Big Steps toward Quantum Computing," *Phys.org*, November 6, 2015; Institute for Quantum Computing, University of Waterloo, "Quantum Computing 101."
16. Guy T. Almes and Karen A. Wetzel, "Science DMZ: ECAR-WG Technology Spotlight," research bulletin (Louisville, CO: ECAR, November 11, 2015).

17. See PKI (public key infrastructure) definition from TechTarget.

18. See Affective Computing.

19. Susan Grajek and the 2015–2016 EDUCAUSE IT Issues Panel, "The Top 10 IT Issues 2016: Divest, Reinvest, Differentiate," *EDUCAUSE Review* 51, no. 1 (January/February 2016).

20. Primary sources were *The Horizon Report*, Gartner's Top 10 Strategic Technology Trends for 2014, and multiple 2014 Gartner Hype Cycles (education, big data, cloud computing, cloud security, enterprise architecture, enterprise information management, GRC, identity and access management, IT operations management, privacy, business intelligence and analytics, and emerging technologies). We augmented those with several additional technologies, most notably in analytics.